Empirical Analysis of Historical Air Quality and Emissions Information to Develop Observationally Based Models of Ozone-VOC-NOx Relationships in Southern California

Final Report Appendix
To the Coordinating Research Council

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Appendix A: Ozone Concentration and Sensitivity Isopleths of the Empirical Models: Inividual site model, Spatially Integrated Model, and the Difference Between the Two Methods

The regression approach was first applied to each of the individual sites included in this study independently by using the local observed ODV as the response variable and basin-wide emissions as independent variables, and was then extended to develop a single model that included spatial variables to develop a single model that could estimate ozone levels across the SoCAB. We show the ozone and sensitivity isopleths for each individual site based on two different empirical methods and the comparison between those two.

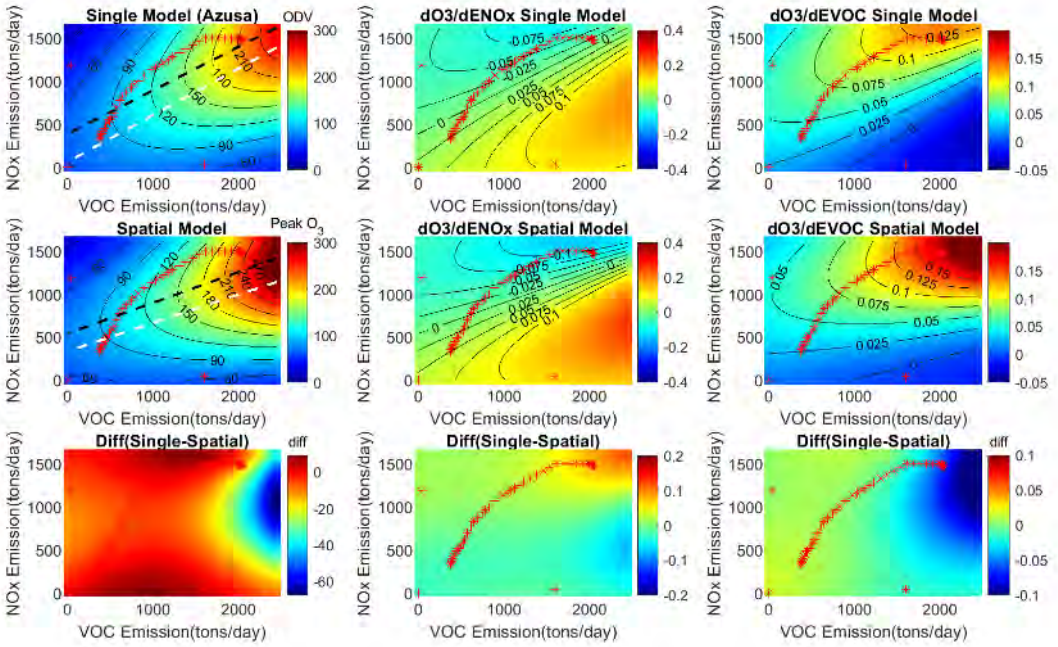
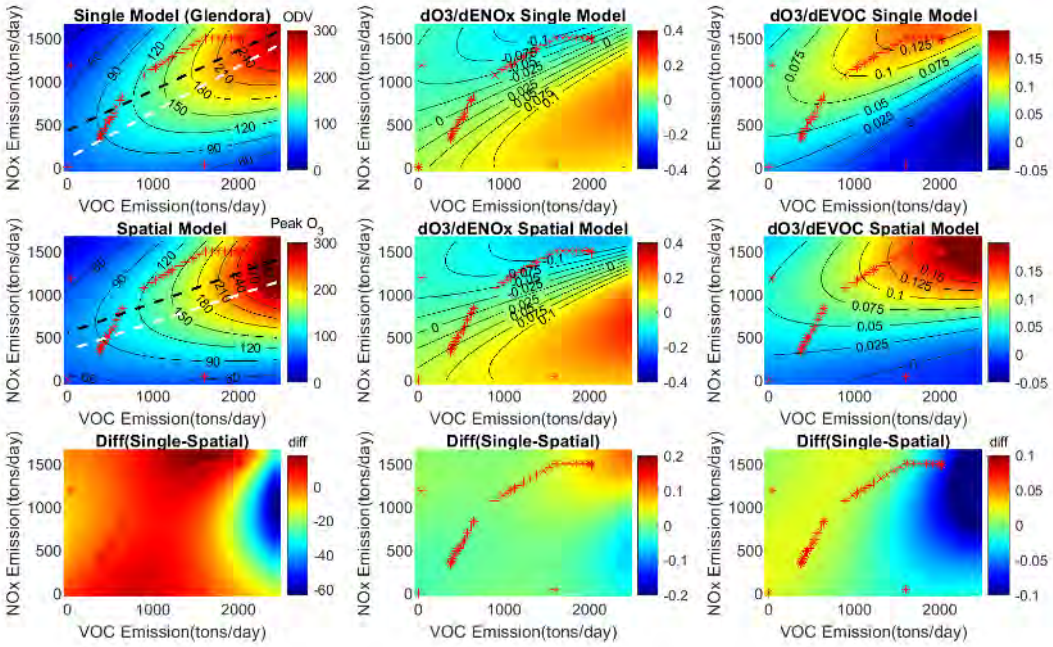
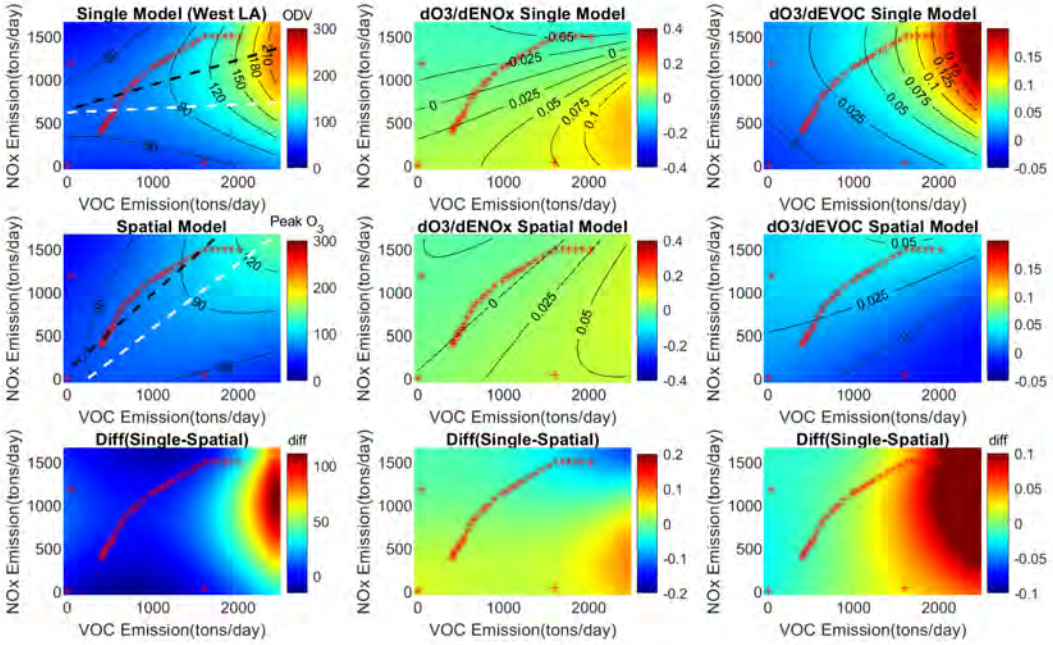
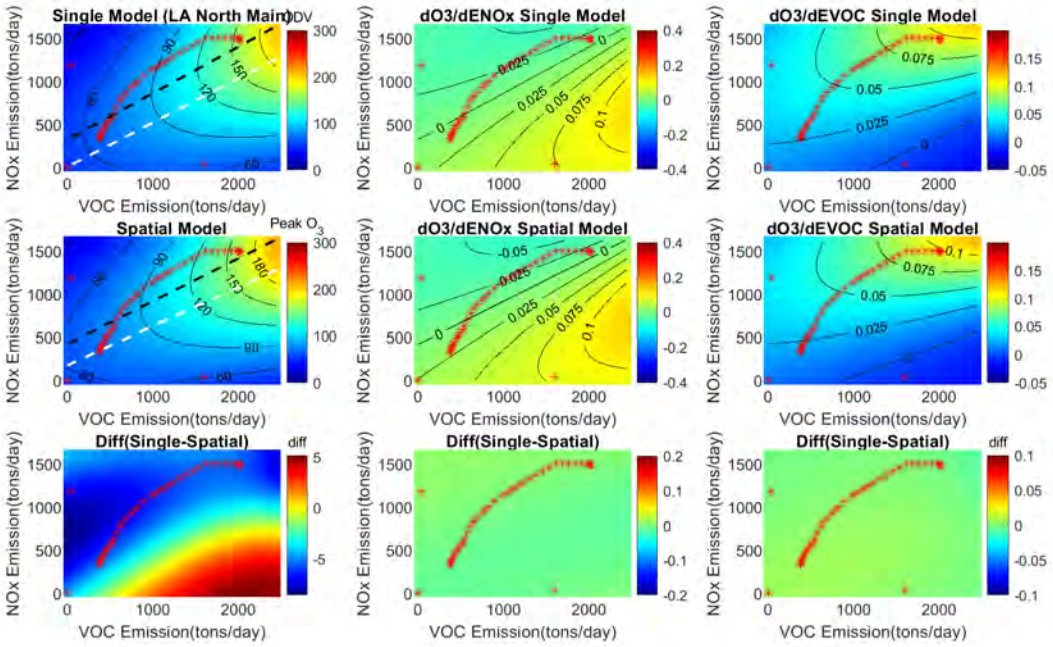
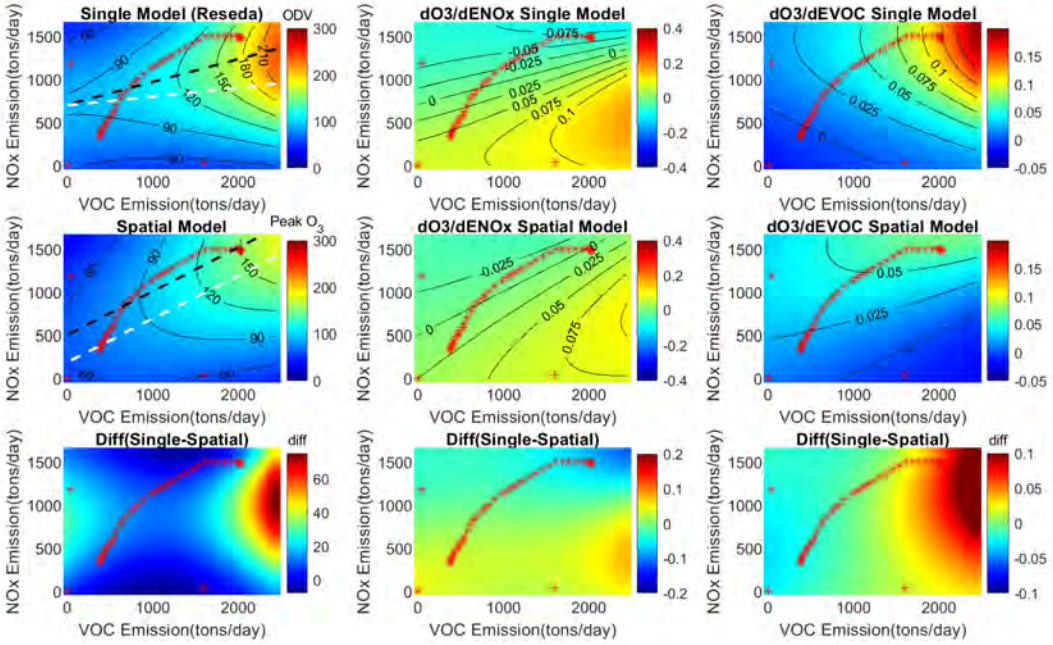


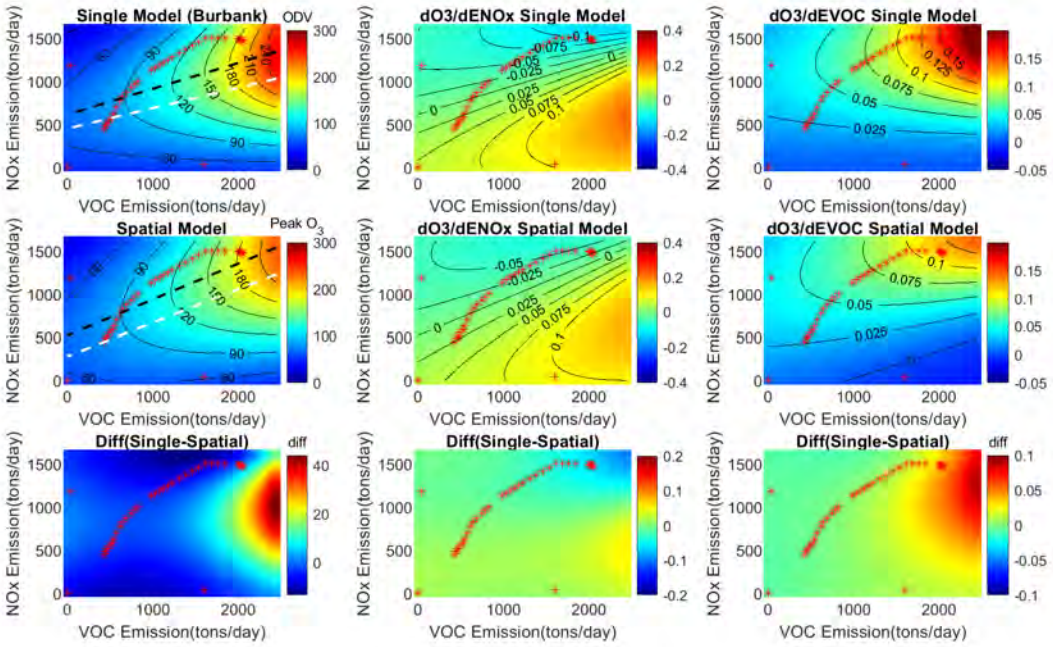
Figure A.1 The empirically based ozone-emissions concentrations and sensitivity isopleth based on both individual-site model and spatially integrated model, and the comparison between methods. The first row shows the individual-site model derived isopleths. The second row shows the spatially integrated model-based isopleths. The third row shows the difference between those two. The first column shows the ozone concentration isopleths; the second column shows the ozone-to-NOx emissions sensitivity isopleths; and the third column shows the ozone-to-VOC emissions sensitivity isopleths. The black dash line indicates the zero-NOx-sensitivity line, and the white dash line indicates the equal-NOx-VOC sensitivity line. The site is Azusa. Results for other sites shown below in this section follow the same layout.

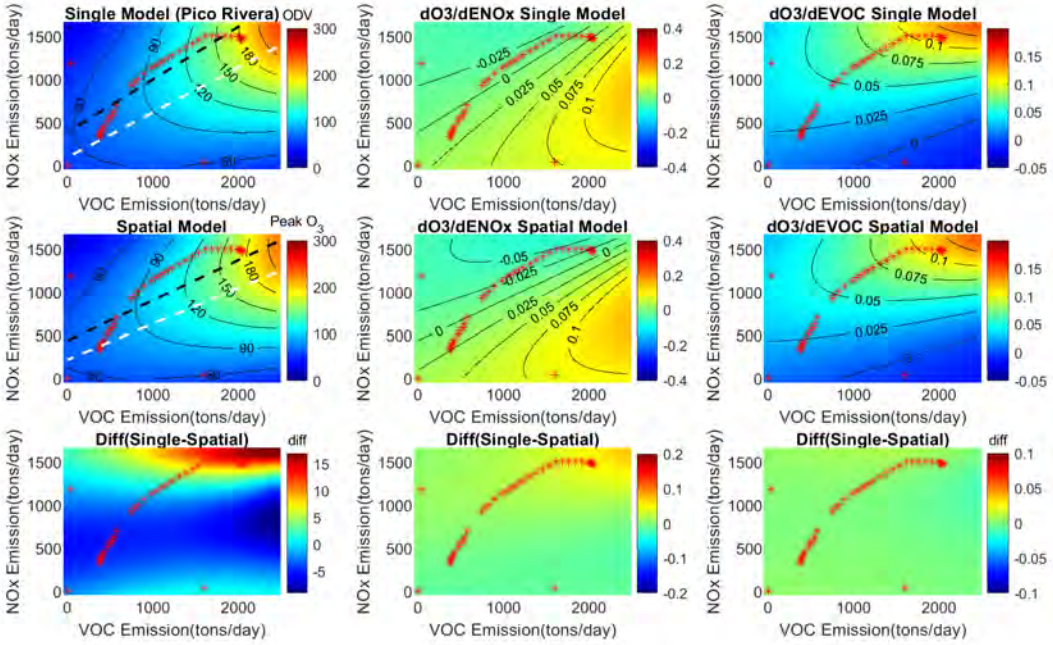

Single Model (Glendora)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

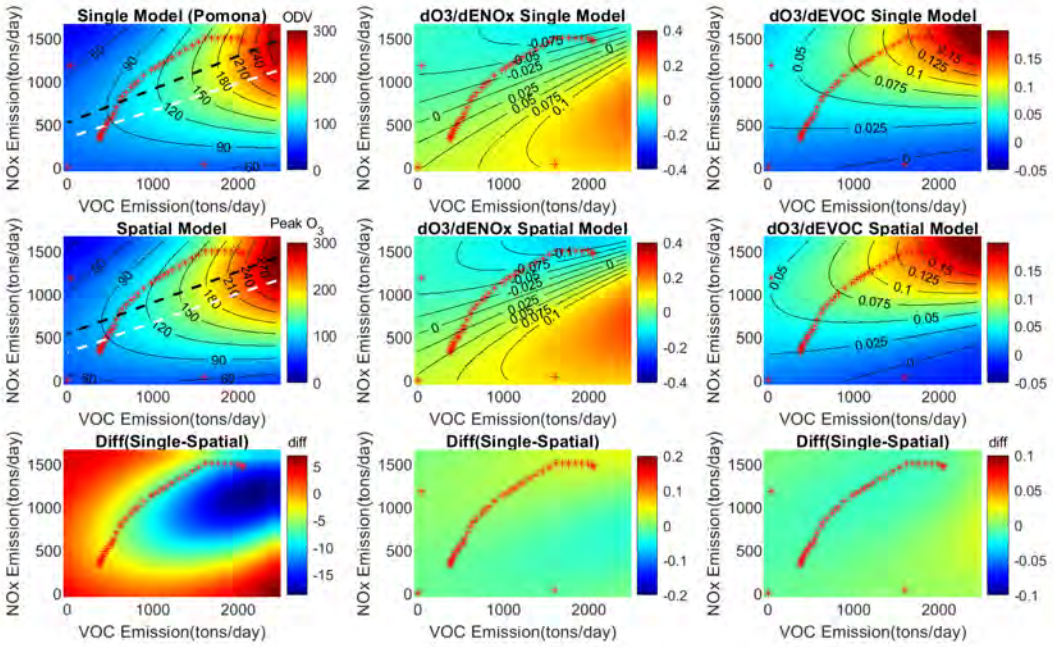

Single Model (West LA)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

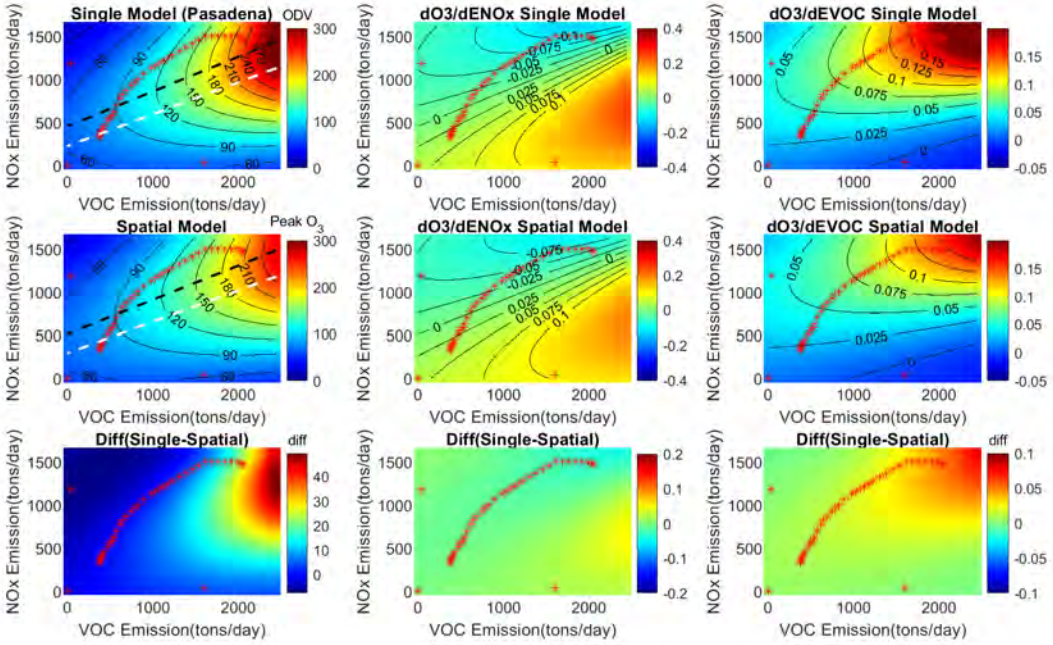

Single Model (LA North Main)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

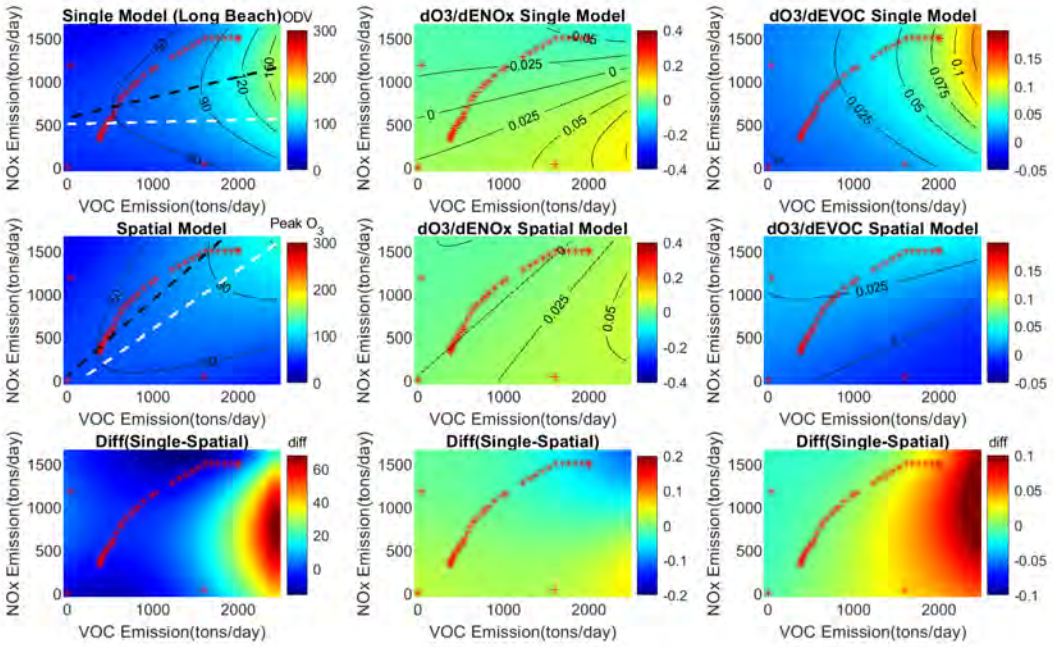

Single Model (Reseda)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

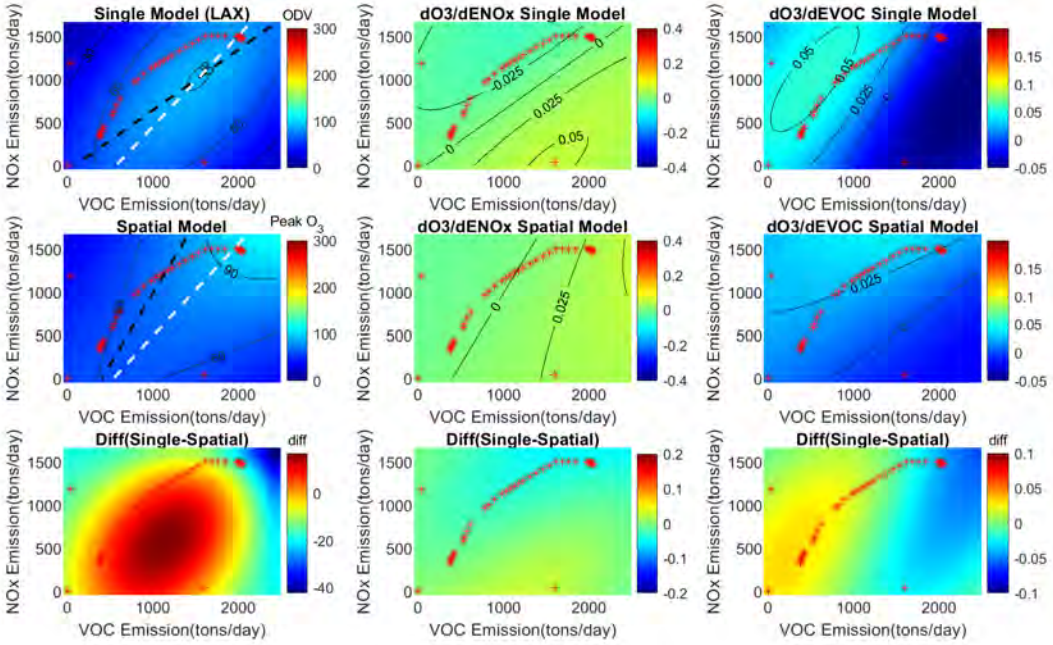

Single Model (Burbank)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

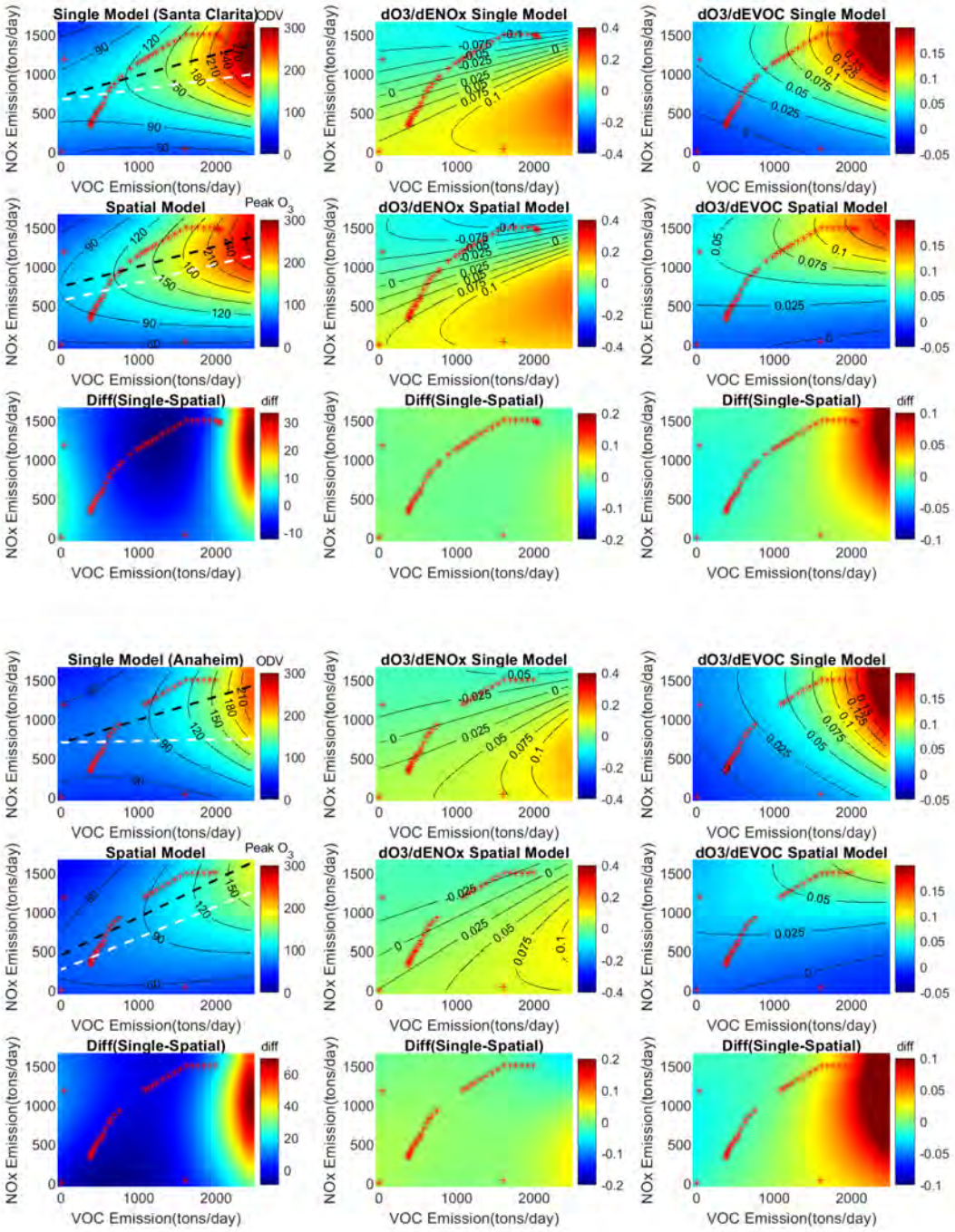

Single Model (Pico Rivera)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

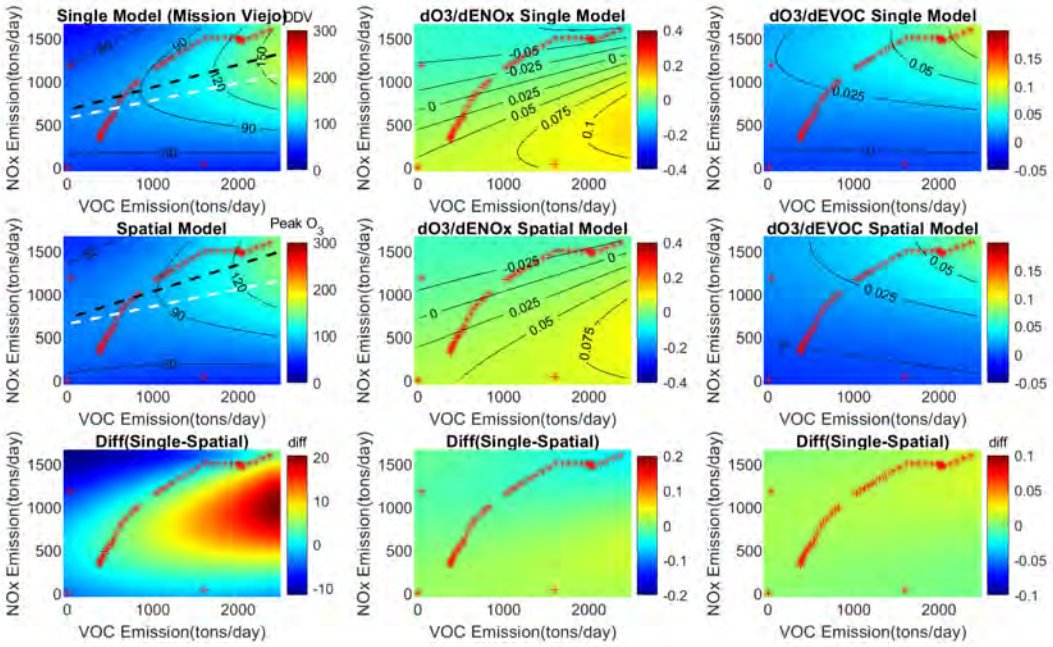

Single Model (Pomona)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Diff(Single-Spatial)
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

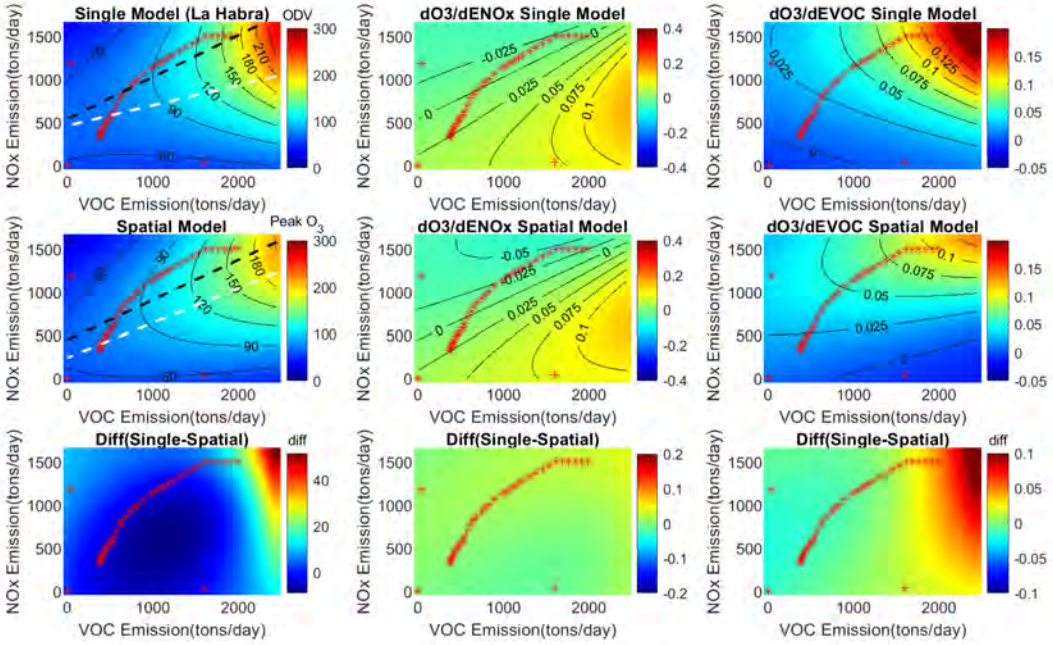

Single Model (Pasadena)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Diff(Single-Spatial)
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

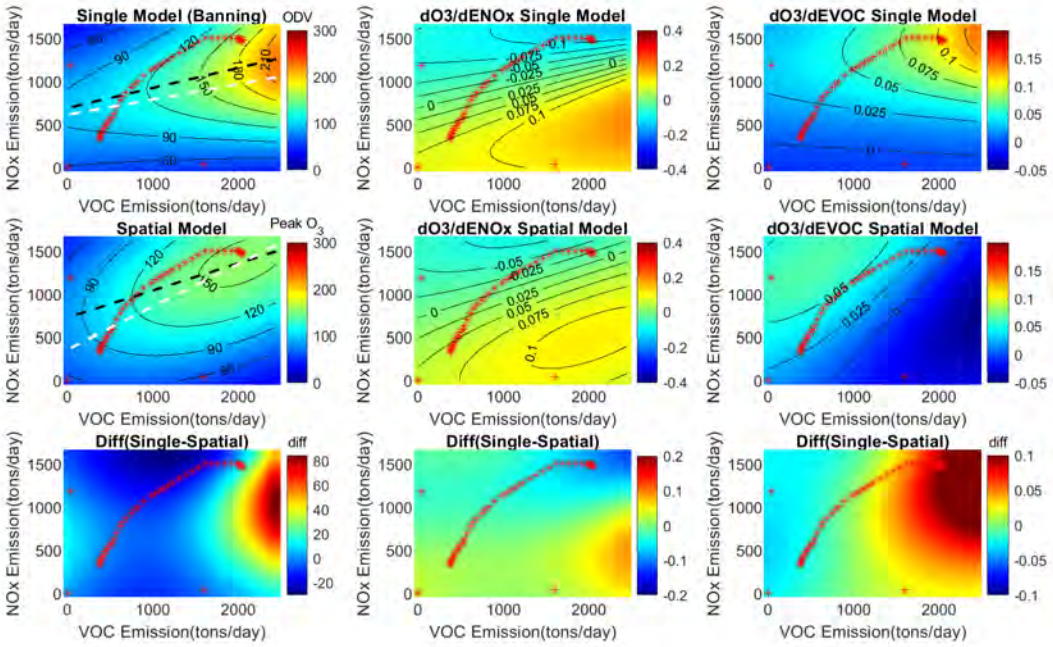

Single Model (Long Beach)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

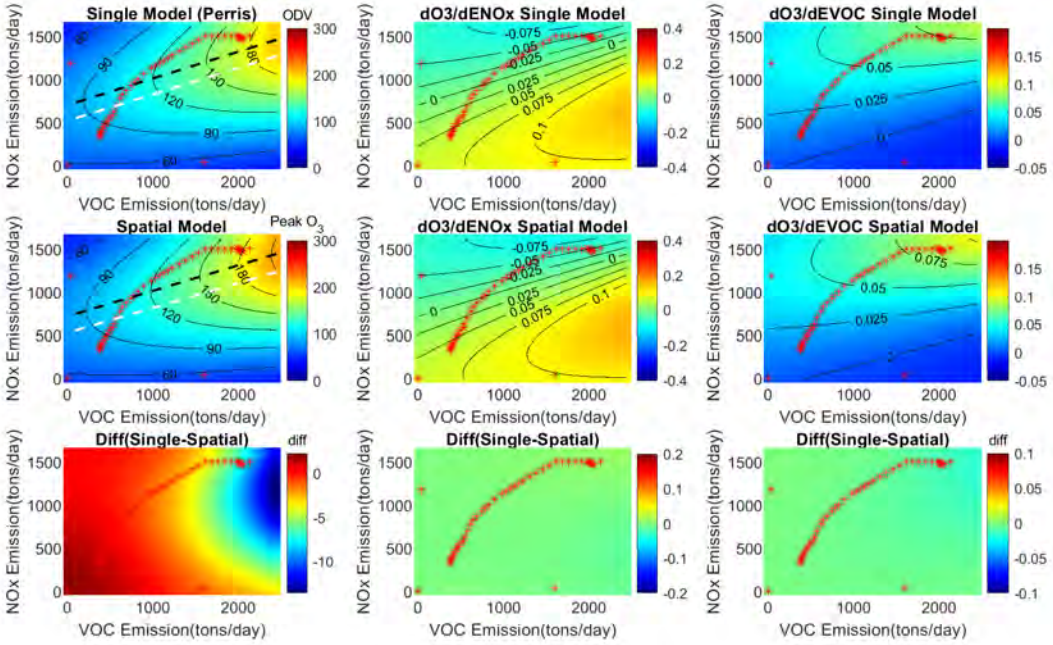

Single Model (LAX)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

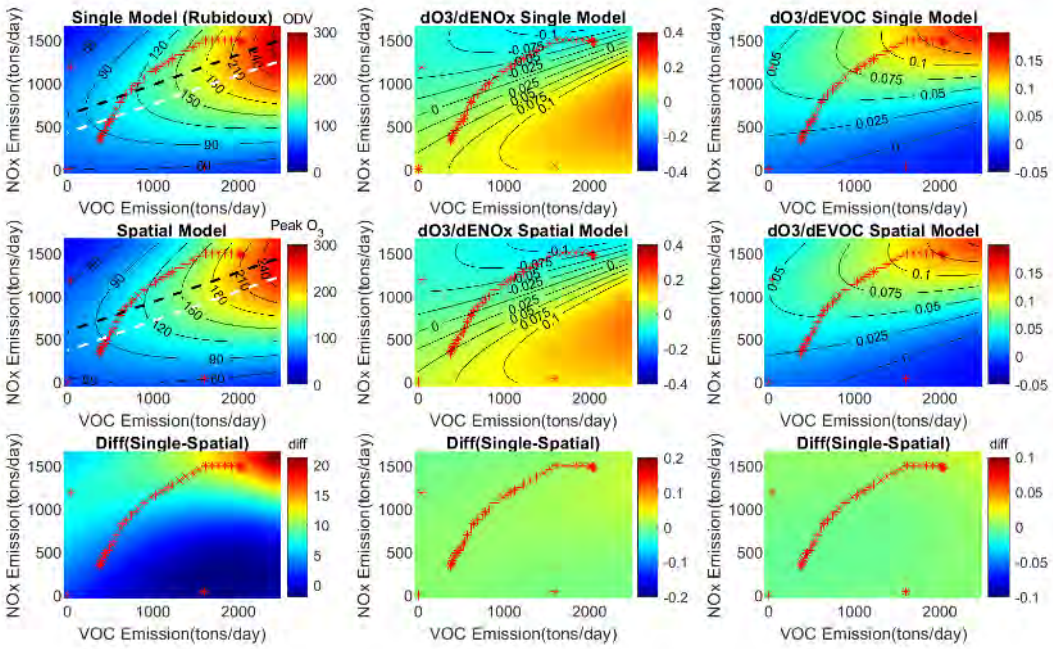

Single Model (Santa Clarita)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Diff(Single-Spatial)
Diff(Single-Spatial)
diff
Single Model (Anaheim)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Diff(Single-Spatial)
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

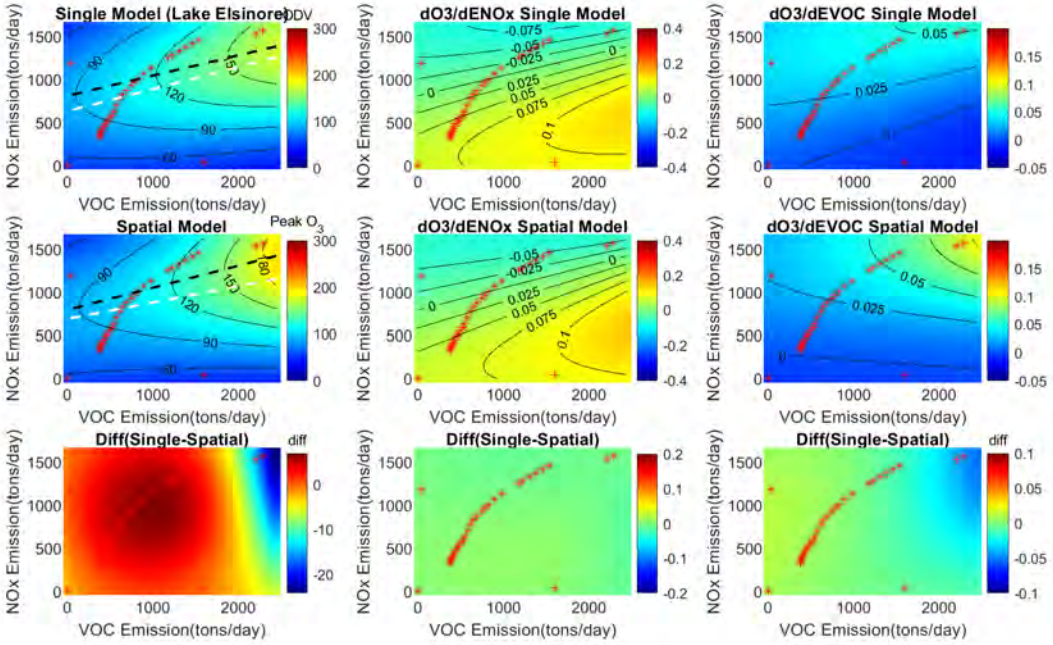

Single Model (Mission Viejo)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

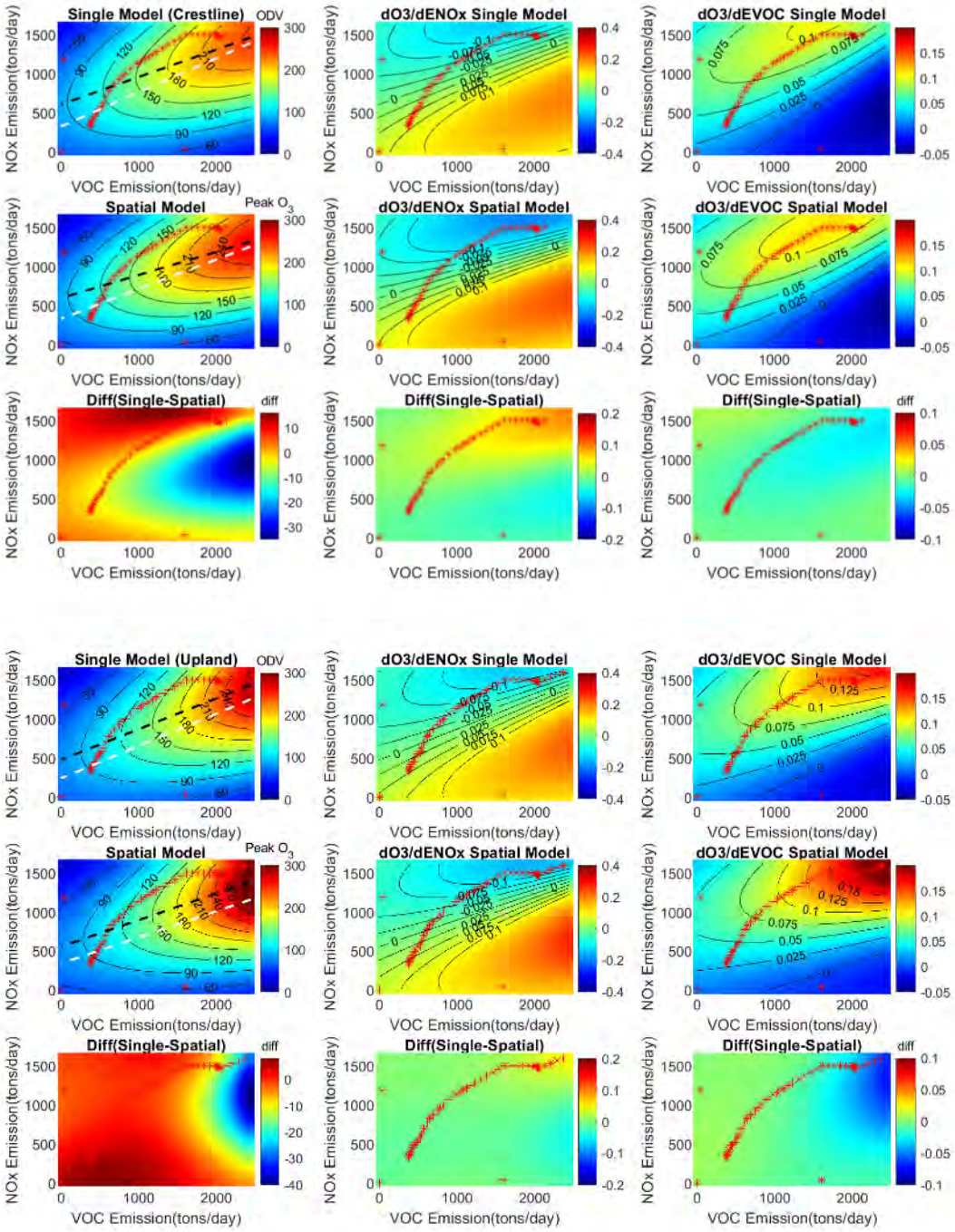

Single Model (La Habra)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

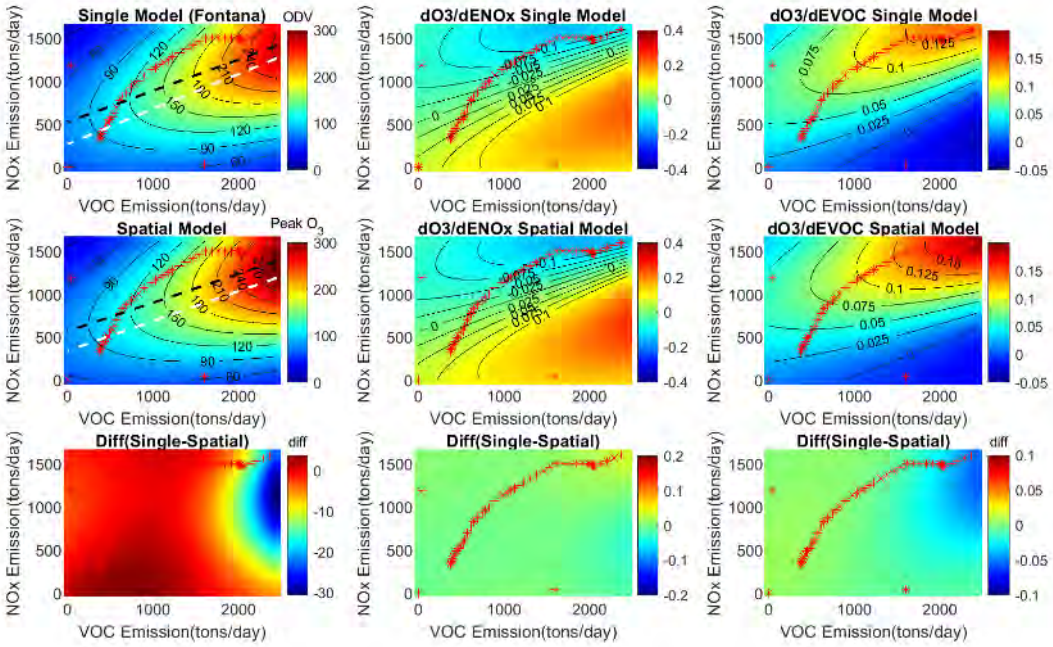

Single Model (Banning)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Diff(Single-Spatial)
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

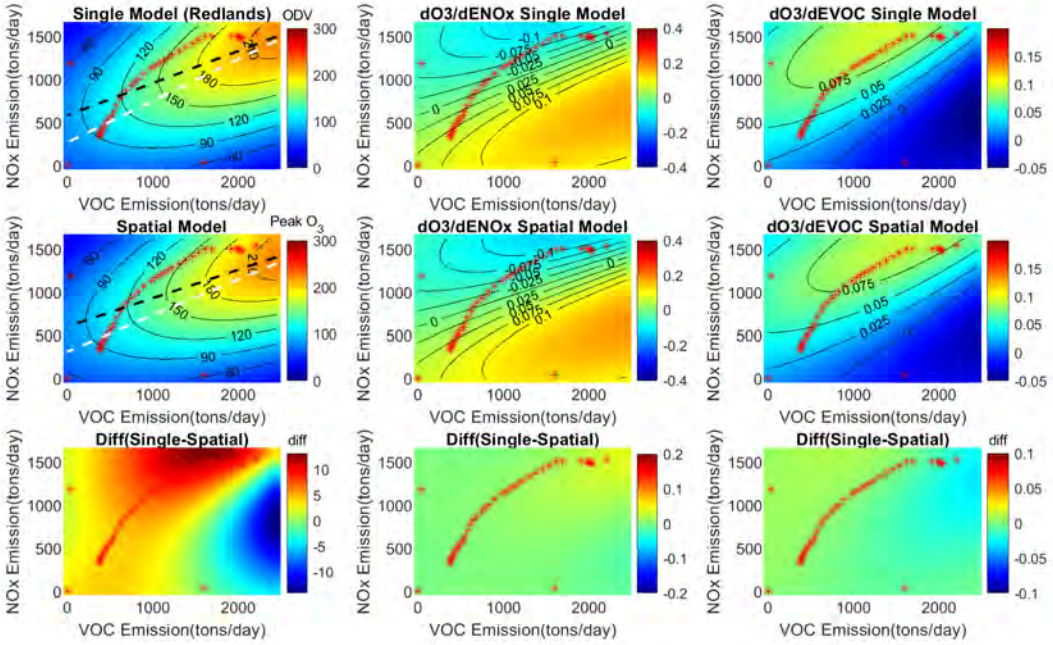

Single Model (Perris)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Diff(Single-Spatial)
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

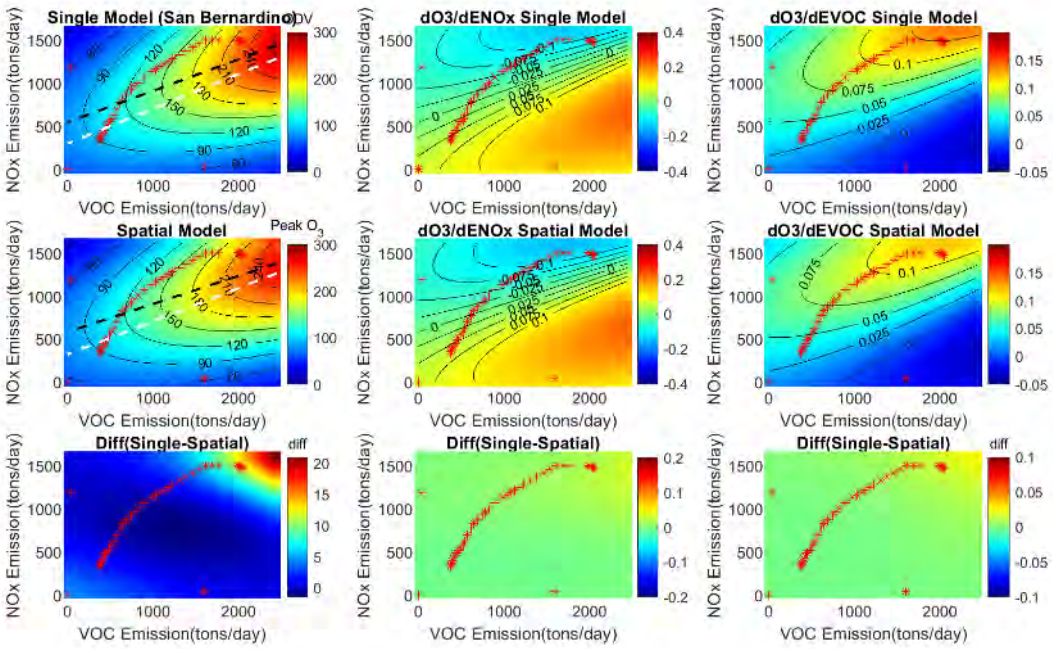

Single Model (Rubidoux)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)


Single Model (Lake Elsinore)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)


Single Model (Crestline)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
Single Model (Upland)
NOx Emission(tons/day)
VOC Emission(tons/day)


Single Model (Fontana)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)


Single Model (Redlands)
ODV
dO3/dENOx Single Model
dO3/dEVOC Single Model
Spatial Model
Peak O3
dO3/dENOx Spatial Model
dO3/dEVOC Spatial Model
Diff(Single-Spatial)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)


Single Model (San Bernardino)
ppb
Spatial Model
Peak O3
Diff(Single-Spatial)
diff
dO3/dENOx Single Model
dO3/dENOx Spatial Model
dO3/dEVOC Single Model
dO3/dEVOC Spatial Model
NOx Emission(tons/day)
VOC Emission(tons/day)

Appendix B: CMAQ-Simulation Configuration and Model Evaluation

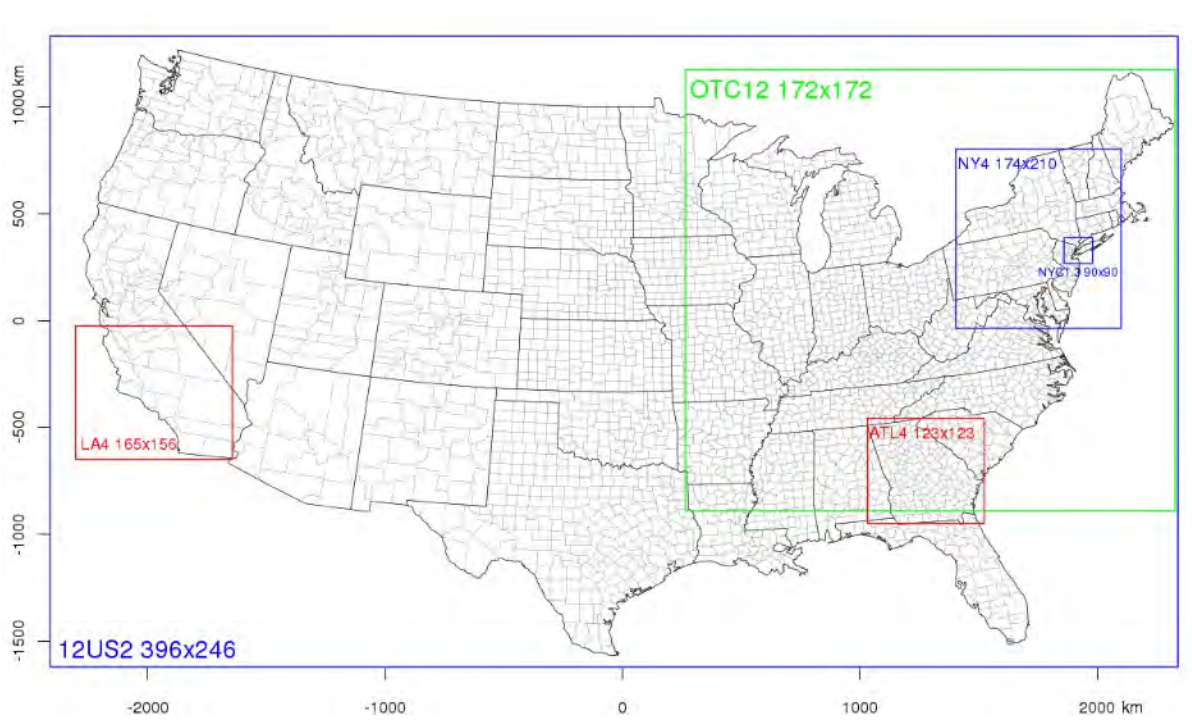


Figure B.1 Map of the modeling domain for the US 12 km resolution and the location and size of LA4 (southern California 4km resolution) domain.

Table B.1 Model configurations for WRF modeling

Physics	**Configuration used**	
	12-km	**4-km**
Longwave radiation	rrtmg scheme	
Shortwave radiation	rrtmg scheme	
Land surface	Pleim-Xiu LSM	
Cumulus	Kain-Fritsch scheme	
Microphysics	Morrison (2 moments)	
PBL	ACM2 (Pleim) PBL	
Surface nudging	on	
Grid nudging	Above the 19th model level	off
Soil nudging	on	off

Table B.2 Performance Evaluation Statistics of the WRF Simulated Meteorological Fields against TDL Hourly Observations for ozone season in 2016

Year	WS Bias	WS RMSE	WD Bias	WD GE	TMP Bias	TMP GE	Hmd Bias	Hmd GE
benchmark	$\leq \pm 0.5$ m/s	≤ 2 m/s	$\leq \pm 10$ deg	≤ 30 deg	$\leq \pm 0.5$ K	≤ 2 K	$\leq \pm 1$ g/kg	≤ 2 g/kg
12US2	0.36	1.85	4.78	32.27	0.15	1.50	0.34	1.08
LA4	-0.2	1.43	1.93	39.10	0.05	1.68	0.25	1.01

$$\text{Bias} = \frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)$$

$$\text{GE} = \frac{1}{N}\sum_{i=1}^{N}|P_i - O_i|$$

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(P_i - O_i)^2}$$

where N is the number of observation (O) and simulation (P) pairs

Appendix C: Development of the 1985 Emissions Inventory and Comparisons of the Emissions Inventories for 1985, 2001, 2011, 2016, and 2028 NEI's Used for the CMAQ-HDDM Simulations

Calculation Method of 1985 Emissions Inventory

All calculations are based on each county and each sector:

Emissions change based on CARB (ec_0):

$$ec_0 = \frac{E_{(total,1985,CARB09)}}{E_{(total,2016,CARB16)}} * \frac{E_{(total,2000,CARB16)}}{E_{(total,2000,CARB09)}} \qquad Equation\ C.1$$

E_{total} is the county-level total emissions of each sector.

Emissions change based on calculation and 2016ff (ec_1):

$$ec_1 = \frac{E_{(total,1985,calculated)}}{E_{(total,2016,2016ff)}} = \frac{ec_0 * E_{(total,2016,calculated)}}{E_{(total,2016,2016ff)}} = \frac{ec_0 * \sum_x \sum_y pc(x,y) * E(x,y,2016,2016ff)}{E_{(total,2016,2016ff)}} \qquad Equation\ C.2$$

pc(x,y) is the population change weight for each grid;

E(x,y,2016,2016ff) is the 2016ff-based 2016 emissions for each grid.

Theoretically, $E_{(total,2016,calculated)} = E_{(total,2016,2016ff)}, which\ means\ ec_1 = ec_0.$

Spatial Distribution Difference between population and emissions:

$$pc(x,y) = \frac{\left(\frac{POP(x,y,1985)}{POP(total,1985)}\right)}{\left(\frac{POP(x,y,2016)}{POP(total,2016)}\right)} \qquad Equation\ C.3$$

An assumption is that the population spatial distribution is same as the area source emissions distribution:

$$\frac{POP(x,y,2016)}{POP(total,2016)} = \frac{E(x,y,2016,2016ff)}{E(total,2016,2016ff)} \qquad Equation\ C.4$$

Integrating equation 4 into equation 2 and rearranging gives:

$$ec_1 = ec_0 * \sum_x \sum_y \frac{\left(\frac{POP(x,y,1985)}{POP(total,1985)}\right)}{\left(\frac{POP(x,y,2016)}{POP(total,2016)}\right)} * \frac{E(x,y,2016,2016ff)}{E_{(total,2016,2016ff)}} = ec_0 * \sum_x \sum_y \frac{POP(x,y,1985)}{POP(total,1985)}$$

$$= ec_0 \qquad Equation\ C.5$$

When Equation 4 is not true, then we need to calculate the scale the difference (r) between ec_0 and ec_1:

$$r = \frac{ec_0}{ec_1} = ec_0 * \frac{E_{(total,2016,2016ff)}}{ec_0 * \sum_x \sum_y pc(x,y) * E(x,y,2016)} = \frac{E_{(total,2016,2016ff)}}{\sum_x \sum_y pc(x,y) * E(x,y,2016)} \qquad Equation\ C.6$$

to make $E_{(total,2016,calculated)} = E_{(total,2016,2016ff)}$, so we need to multiply the denominator by the scale difference (r):

$$\frac{E_{(total,2016,2016ff)}}{r * \sum_x \sum_y pc(x,y) * E(x,y,2019)} = 1 \qquad Equation\ C.7$$

Then the effective calculated 1985 emissions become:

$$E_{(total,1985,calculated)} = ec_0 * r * \sum_x \sum_y pc(x,y) * E(x,y,2016,2016ff) \qquad Equation\ C.8$$

We can define the adjusted emissions change (ec_2):

$$ec_2 = r * ec_0 \qquad Equation\ C.9$$

which will be used to conduct a second step adjustment of emissions fields.

Other factors:

we transform the equation to:

$$r = \frac{ec_0}{ec_1} = \frac{E_{(total,1985,CARB09)}}{E_{(total,2016,CARB16)}} * \frac{E_{(total,2000,CARB16)}}{E_{(total,2000,CARB09)}} * \frac{E_{(total,2016,2016ff)}}{ec_0 * \sum_x \sum_y pc(x,y) * E(x,y,2016)} \qquad Equation\ C.10$$

$$1 = \frac{ec_0}{r * ec_1} = \frac{E_{(total,1985,CARB09)}}{E_{(total,2016,CARB16)}} * \frac{E_{(total,2000,CARB16)}}{E_{(total,2000,CARB09)}} * \frac{E_{(total,2016,2016ff)}}{r * ec_0 * \sum_x \sum_y pc(x,y) * E(x,y,2016)} \qquad Equation\ C.11$$

Rearrange the equation:

$$E_{(total,1985,CARB09)} = \frac{E_{(total,2016,CARB16)}}{E_{(total,2016,2016ff)}} * \frac{E_{(total,2000,CARB09)}}{E_{(total,2000,CARB16)}} * r * ec_0 * \sum_x \sum_y pc(x,y) * E(x,y,2019) \qquad Equation\ C.12$$

$$E_{(total,1985,CARB09)} * \frac{E_{(total,2016,2016ff)}}{E_{(total,2016,CARB16)}} * \frac{E_{(total,2000,CARB16)}}{E_{(total,2000,CARB09)}} = r * ec_0 * \sum_x \sum_y pc(x,y) * E(x,y,2019) = E_{(total,1985,calculated)} \qquad Equation\ C.13$$

We can define the adjusted emissions change (ec_3):

$$ec_3 = \frac{E_{(total,2016,CARB16)}}{E_{(total,2016,2016ff)}} * \frac{E_{(total,2000,CARB09)}}{E_{(total,2000,CARB16)}} * r * ec_0 \qquad Equation\ C.14$$

With this adjustment:

$$\frac{E_{(total,1985,CARB)}}{ec_3 * \sum_x \sum_y pc(x,y) * E(x,y,2016)} = 1 \qquad Equation\ C.15$$

The target is to make $E_{(total,1985,calculated)} = E_{(total,1985,CARB)}$

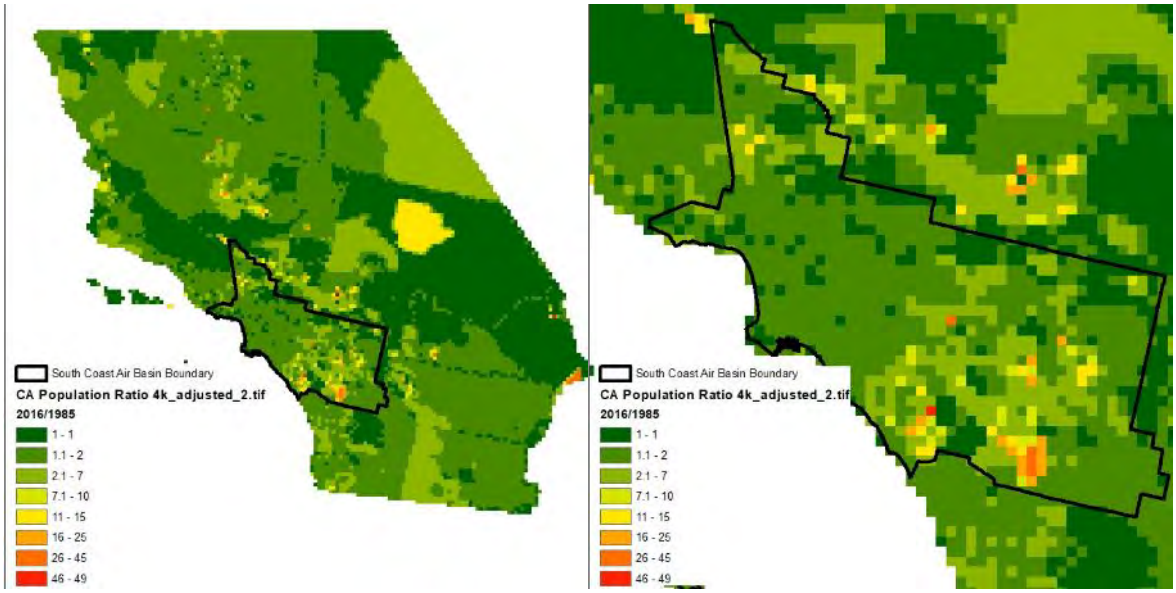


Figure C.0.1 Spatial map of population ratio between 2016 and 1985 for LA4 modeling domain for each 4km grid.

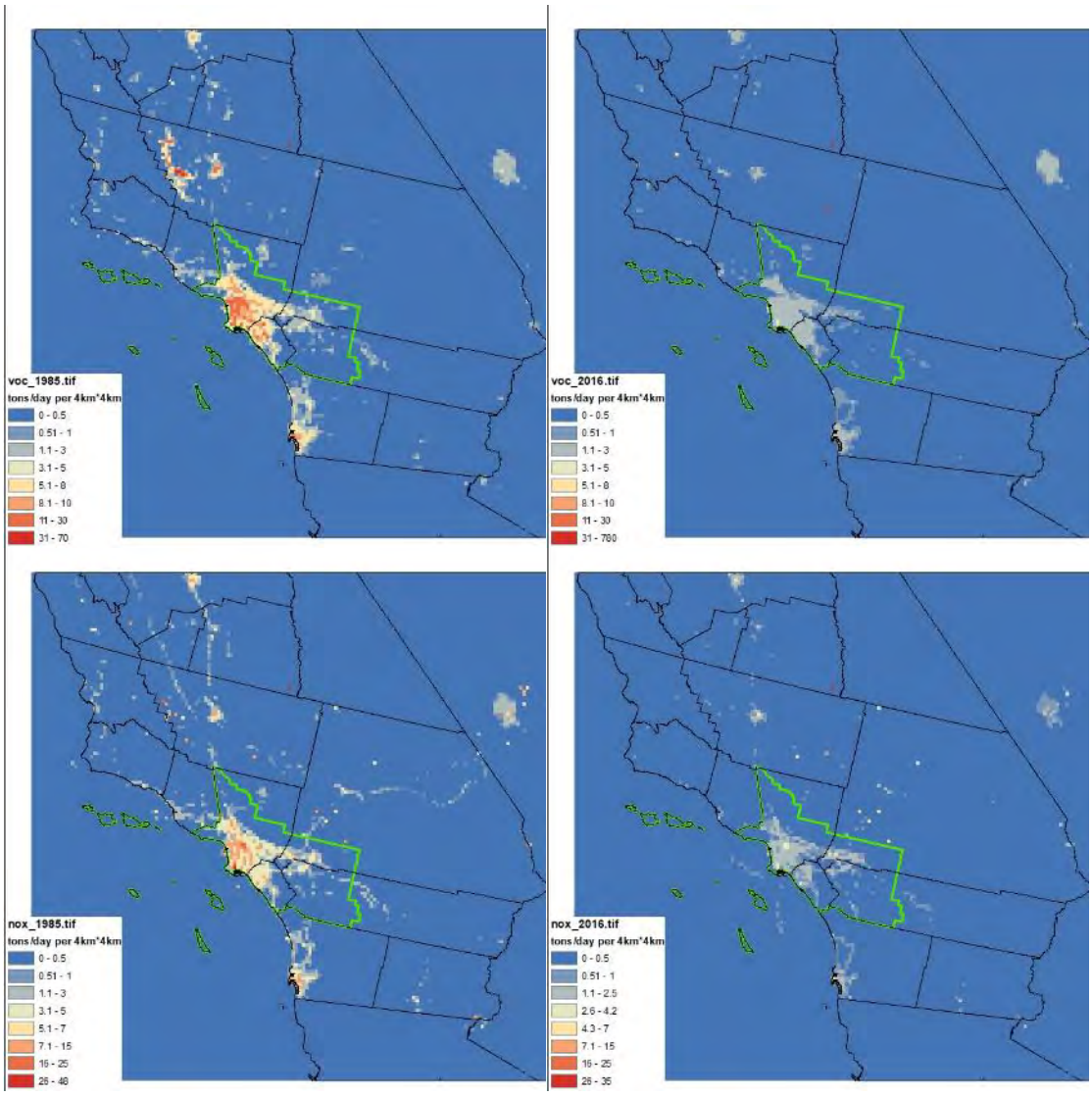


Figure C.0.2 Spatial distribution of VOC and NOx emissions for 1985 and 2016 respectively.

Table C.1 Comparison of the county level emissions total between rescaled 1985 emissions and the CARB 1985 emissions.

	VOC		CO		NOx		SO2		PMC		PM 2.5	
Tongs/day	2016ff	CARB	2016ff	CARB	2016ff	CARB	2016ff	CARB	2016ff	CARB	2016ff	CARB
Fresno	128.1	134.9	715.3	761.4	146.0	162.5	30.3	37.4	27.6	46.6	15.3	28.2
Imperial	25.0	32.8	186.2	183.2	35.4	34.2	3.2	3.6	62.7	213.9	11.1	42.0
Inyo	5.9	7.8	42.2	53.9	4.6	5.9	2.6	1.4	117.9	697.9	17.6	129.7
Kern	789.1	637.0	834.3	890.8	270.1	379.8	31.9	65.7	29.7	51.2	20.3	38.8
Kings	29.1	24.2	205.8	108.0	27.5	26.0	3.6	4.2	30.6	15.8	17.9	6.7
Los Angeles	1536.9	1518.5	10398.5	9055.3	1133.8	1111.5	74.4	90.0	39.4	112.9	67.9	79.2
Monterey	26.0	70.2	129.3	540.0	25.0	85.7	19.3	12.0	4.4	22.2	5.4	10.3
Orange	455.5	431.4	2720.5	2412.2	263.2	270.7	11.6	14.8	7.7	25.4	15.4	16.8
Riverside	164.8	175.6	1234.5	1099.6	169.8	153.3	10.0	8.7	18.1	32.0	11.9	15.9
San Benito	0.8	10.2	3.3	66.4	0.5	12.6	0.0	1.4	0.4	8.5	0.1	3.7
San Bernardino	238.6	232.8	1724.7	1367.7	313.3	289.9	20.2	21.7	32.2	93.7	25.5	52.6
San Diego	428.0	399.7	2831.9	2893.6	293.2	268.6	22.1	21.0	32.3	59.3	19.4	24.3
San Luis Obispo	43.4	49.6	308.4	305.4	41.4	51.7	12.1	18.8	5.8	17.4	3.3	6.8
Santa Barbara	62.3	76.0	352.9	485.1	47.9	77.5	6.1	16.1	6.3	11.6	3.4	6.5
Tulare	61.5	59.6	391.6	357.0	69.8	56.9	5.3	5.3	33.2	18.2	10.9	10.3
Ventura	106.9	105.2	652.9	631.4	92.9	97.3	3.1	7.0	5.3	11.6	4.3	7.5
sum	4102.1	3965.6	22732.5	21211.0	2934.5	3084.1	255.9	329.2	453.7	1438.4	249.7	479.4

Table C.2 Summary of county level emissions total for 2001, 2011, 2016, and 2028 used for CMAQ-HDDM simulations. And the comparison between NEI platform and CARB inventories.

2002ef		voc	co	nox	so2	pmc	pm25	CARB		VOC	CO	NOx	SO2	PMC	PM2.5
2001	Fresno	136.9	379.5	154.1	13.1	27.7	10.3	2001	Fresno	99.4	380.1	147.9	3.3	62.6	26.0
nofire	Imperial	78.6	126.5	52.9	6.0	38.8	8.0	v16	Imperial	23.4	100.4	38.2	1.2	274.4	44.8
	Inyo	3.4	11.9	4.5	0.5	3.9	0.8	nofire	Inyo	5.6	25.1	5.4	0.7	202.5	37.3
	Kern	151.2	442.0	299.5	9.8	33.5	15.1		Kern	120.3	351.7	200.2	9.7	48.3	24.7
	Kings	42.2	73.4	44.8	1.5	12.6	3.3		Kings	29.0	68.7	31.7	0.5	25.3	8.0
	Los Angel	607.1	3466.5	930.4	71.6	78.2	41.2		Los Angel	577.6	3152.5	716.2	60.9	52.9	55.7
	Monterey	19.3	75.3	26.1	1.3	7.4	1.9		Monterey	41.5	190.9	63.2	8.6	18.4	8.1
	Orange	194.4	985.9	238.6	17.4	27.1	11.7		Orange	175.2	901.0	171.6	5.7	12.9	12.7
	Riverside	148.7	718.6	262.7	9.7	42.8	10.7		Riverside	102.4	544.6	189.6	2.6	32.9	14.0
	San Benit	2.0	4.3	3.0	0.1	0.4	0.1		San Benit	5.7	24.6	10.8	0.1	7.0	1.6
	San Berna	197.8	1017.1	408.3	11.4	63.1	22.5		San Berna	142.2	767.1	347.0	11.7	58.9	33.9
	San Diego	236.4	1157.0	279.2	10.6	58.7	19.3		San Diego	202.5	1023.8	227.7	6.4	55.2	26.9
	San Luis O	39.5	172.7	50.2	14.5	12.9	7.0		San Luis O	27.2	143.5	39.6	16.8	8.1	5.7
	Santa Bart	55.1	226.0	96.5	24.9	9.5	6.3		Santa Bart	39.4	169.3	81.9	32.0	9.7	7.6
	Tulare	124.0	203.6	78.1	3.2	16.7	7.4		Tulare	69.2	182.0	61.8	0.9	33.1	10.8
	Ventura	73.2	320.2	108.5	14.1	12.0	7.9		Ventura	57.2	277.2	66.9	9.1	10.5	7.6
	sum	2109.9	9380.4	3037.3	209.6	445.2	173.5		sum	1718.0	8302.4	2399.8	170.1	912.7	325.5
2011ek		voc	co	nox	so2	pmc	pm25	CARB		VOC	CO	NOx	SO2	PMC	PM2.5
2011	Fresno	53.4	168.4	85.8	1.5	20.2	9.0	2011	Fresno	66.7	176.2	91.1	1.6	48.9	16.8
nofire	Imperial	14.4	61.8	27.0	0.2	46.5	8.2	v16	Imperial	16.6	66.3	23.4	0.5	250.2	40.5
	Inyo	2.0	6.5	1.5	0.2	3.3	0.9	nofire	Inyo	3.6	12.3	3.2	0.5	28.5	5.0
	Kern	85.1	185.7	118.9	6.4	25.9	14.2		Kern	86.2	189.4	120.8	6.2	35.0	18.8
	Kings	10.3	31.2	19.0	0.2	10.0	2.5		Kings	26.7	37.6	20.1	0.3	19.4	5.4
	Los Angel	340.0	1602.7	369.1	12.7	45.2	41.1		Los Angel	309.2	1461.1	376.4	16.8	54.0	44.4
	Monterey	7.3	23.0	9.4	0.2	4.7	1.5		Monterey	31.2	101.4	46.4	2.6	19.4	6.7
	Orange	108.3	476.3	84.1	1.0	10.3	10.3		Orange	97.3	446.7	87.1	1.8	12.4	10.8
	Riverside	76.6	347.9	120.9	0.8	28.4	11.7		Riverside	69.3	296.2	107.2	1.0	36.3	13.8
	San Benit	0.5	1.7	1.1	0.0	0.3	0.1		San Benit	4.2	13.4	7.2	0.0	6.0	1.4
	San Berna	101.3	467.9	208.0	4.5	44.0	26.0		San Berna	91.4	388.7	190.9	5.4	76.3	30.2
	San Diego	131.9	505.7	118.8	1.3	42.1	15.9		San Diego	134.8	507.0	135.2	1.9	49.3	19.7
	San Luis O	17.2	67.4	17.3	0.5	7.6	3.4		San Luis O	19.3	70.9	28.6	6.6	7.4	4.2
	Santa Bart	25.7	75.9	21.5	1.0	8.2	3.3		Santa Bart	31.8	101.9	73.0	11.9	8.9	5.2
	Tulare	28.4	103.9	42.2	0.4	14.1	5.3		Tulare	60.2	98.7	39.8	0.5	27.5	8.3
	Ventura	37.9	147.7	29.2	0.7	8.0	5.3		Ventura	37.2	137.2	42.7	3.0	10.6	6.0
	sum	1040.2	4273.7	1274.0	31.6	318.6	158.6		sum	1085.6	4104.8	1393.1	60.6	690.1	237.2
2016ff		voc	co	nox	so2	pmc	pm25	CARB		VOC	CO	NOx	SO2	PMC	PM2.5
2016	Fresno	41.7	127.1	54.9	0.8	30.8	10.1	2016	Fresno	55.5	117.1	59.4	1.6	49.7	14.1
no fire	Imperial	12.6	48.6	16.4	0.1	57.0	10.3	v16	Imperial	15.3	54.8	17.1	0.3	245.2	39.0
	Inyo	2.2	6.7	1.6	0.5	5.4	1.1	nofire	Inyo	3.4	8.6	2.2	0.5	28.6	4.9
	Kern	61.6	138.5	76.2	4.9	26.4	13.6		Kern	71.2	143.6	86.1	9.6	35.4	18.0
	Kings	8.9	26.7	12.0	0.1	23.6	6.0		Kings	21.1	27.9	13.1	0.2	18.4	4.8
	Los Angel	267.5	1210.2	236.3	11.5	46.6	40.5		Los Angel	249.0	1035.3	269.2	14.5	57.7	41.5
	Monterey	10.7	21.1	6.2	0.2	5.9	1.7		Monterey	29.3	84.2	44.6	1.3	21.2	7.0
	Orange	110.1	445.9	63.4	1.5	11.6	13.8		Orange	80.9	338.4	65.1	1.3	13.3	10.3
	Riverside	60.8	303.5	85.5	1.2	32.7	13.9		Riverside	60.9	223.2	74.3	0.9	42.1	13.1
	San Benit	0.3	0.7	0.2	0.0	0.4	0.1		San Benit	3.7	9.5	4.3	0.0	6.2	1.3
	San Berna	72.5	369.9	145.5	2.9	42.9	23.3		San Berna	74.4	282.5	153.0	4.4	81.4	30.8
	San Diego	109.0	460.5	84.3	1.9	43.5	19.1		San Diego	113.3	389.2	99.0	1.3	56.8	19.4
	San Luis O	12.6	53.4	12.2	0.6	6.2	2.6		San Luis O	17.9	56.7	28.4	1.1	7.7	3.5
	Santa Bart	19.8	58.4	14.3	1.0	7.2	2.6		Santa Bart	28.5	81.3	69.0	2.2	9.8	3.7
	Tulare	20.4	74.8	28.0	0.4	38.2	10.4		Tulare	46.2	61.7	26.2	0.4	27.5	6.7
	Ventura	28.5	115.4	20.9	0.7	8.3	4.0		Ventura	32.6	107.0	36.5	1.5	11.5	5.9
	sum	839.0	3461.4	857.9	28.4	386.6	173.1		sum	903.4	3021.0	1047.7	40.9	712.5	224.0
2028fh		voc	co	nox	so2	pmc	pm25	CARB		VOC	CO	NOx	SO2	PMC	PM2.5
2028	Fresno	35.6	95.4	26.3	0.8	31.5	9.5	2028	Fresno	53.9	84.2	30.8	1.8	51.4	14.1
no fire	Imperial	9.3	29.4	9.0	0.1	57.2	10.1	v16	Imperial	14.5	53.0	12.1	0.2	245.9	39.6
	Inyo	1.5	4.3	1.0	0.4	5.0	1.1	nofire	Inyo	3.2	5.3	1.1	0.5	28.8	5.0
	Kern	51.4	120.6	51.8	4.3	26.9	12.4		Kern	68.5	117.1	57.4	10.9	36.0	17.9
	Kings	7.6	16.9	6.7	0.1	23.4	5.4		Kings	21.4	30.6	9.2	0.2	14.1	4.5
	Los Angel	218.5	935.8	147.2	13.4	47.4	39.8		Los Angel	214.0	724.9	166.7	14.0	64.3	42.5
	Monterey	8.9	16.2	3.8	0.2	6.0	1.8		Monterey	29.1	68.0	46.6	1.5	25.1	7.7
	Orange	99.9	382.8	32.0	1.3	12.3	13.6		Orange	70.1	262.7	37.6	1.3	14.4	10.3
	Riverside	51.0	256.5	45.8	1.1	34.8	13.9		Riverside	60.4	172.1	33.1	0.9	54.2	14.9
	San Benit	0.2	0.7	0.1	0.0	0.5	0.1		San Benit	3.8	7.0	2.2	0.0	6.6	1.4
	San Berna	50.9	277.1	91.5	2.7	42.0	21.8		San Berna	66.1	209.6	112.4	5.4	95.2	35.6
	San Diego	95.1	376.3	42.9	1.9	44.5	18.8		San Diego	102.7	304.7	71.7	1.4	68.2	20.6
	San Luis O	10.5	42.0	6.2	0.6	6.3	2.5		San Luis O	17.1	45.8	30.5	1.3	8.1	3.6
	Santa Bart	16.4	43.7	8.3	0.9	7.4	2.4		Santa Bart	29.0	68.2	86.9	2.9	11.6	4.1
	Tulare	16.3	56.3	14.9	0.4	38.4	10.2		Tulare	44.2	44.7	13.0	0.4	28.4	6.6
	Ventura	22.6	83.0	11.3	0.4	8.6	3.9		Ventura	29.8	82.4	34.2	1.9	12.7	6.3
	sum	695.7	2736.9	498.8	28.6	392.2	167.2		sum	827.7	2280.3	745.4	44.7	765.2	234.5

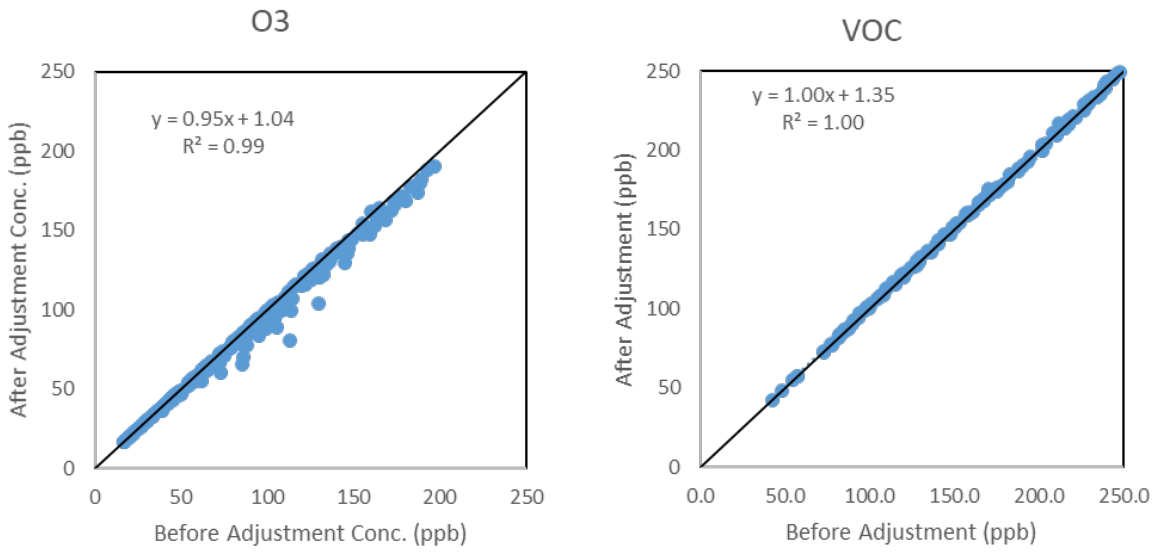


Figure C.3 Comparison of CMAQ-simulated ozone and VOC concentrations between 1985-based and 2016 based VOC emissions compositions.

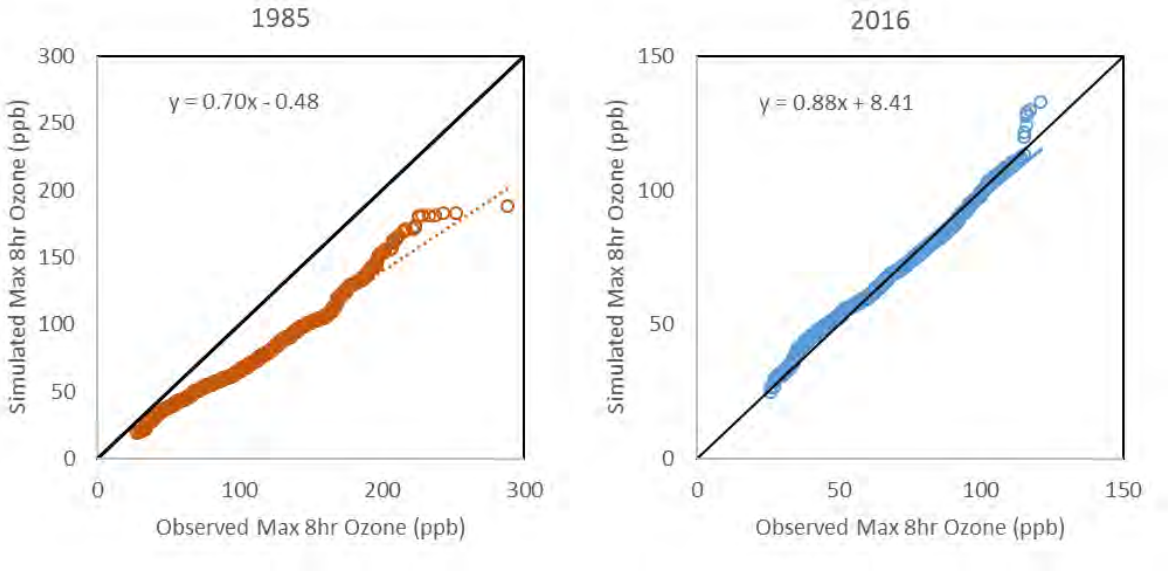


Figure C.4 Comparison between simulated and observed ozone concentrations (ppb) in a rank-ordered base for 1985 and 2016 for all sites together over 3-month high ozone period (May to July).

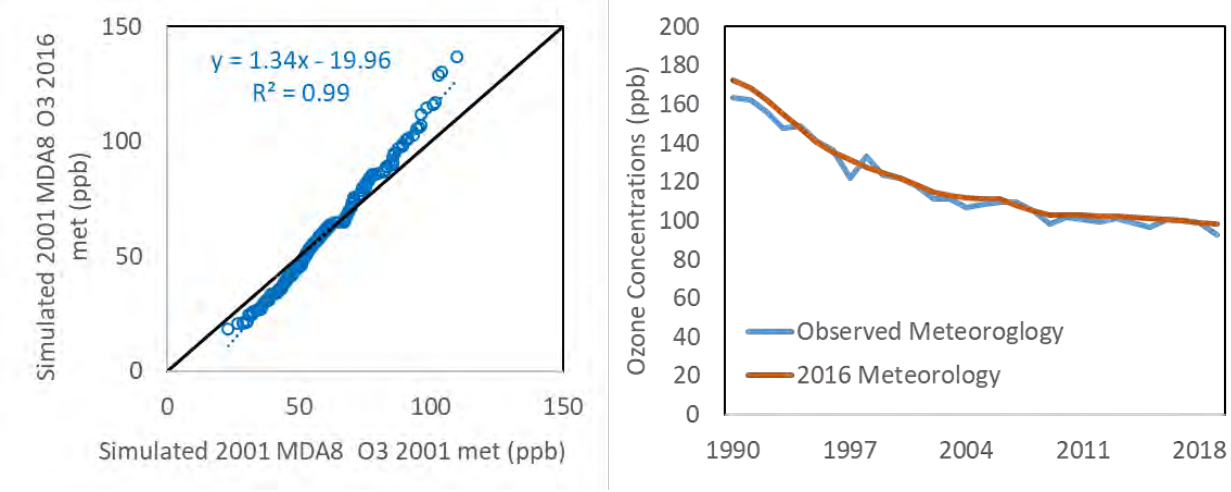


Figure C.5 Comparison of CMAQ-simulated ozone concentration using different meteorology. Left: comparison of simulated ozone concentrations (ppb) in a rank-ordered base for 2011 for all sites together between using 2001 meteorology and using 2016 meteorology. Right: comparison of GAM model-estimated 4th highest ozone concentration trends for Crestline between using observed yearly specific meteorology and using 2016 meteorology for each year.

Calculation of the log-quadratic fitting isopleth

The right-hand sides of equations are derived from assumptions of the quadratic and log quadratic forms (Equation 3.11). Parameters in Equation 3.11 can be derived by minimizing the sum of squared residuals between the left-hand sides and right-hand sides (i.e. cost function in least squares) simultaneously. And ozone isopleth can be developed by using these estimated parameters.

$$\frac{\partial \log(\mathrm{ODV})}{\partial \mathrm{E_{NO_x}}} = \frac{1}{\mathrm{ODV}} \times \frac{\partial \mathrm{ODV}}{\partial \mathrm{E_{NO_x}}}$$

$$\frac{\partial \log(\mathrm{ODV})}{\partial \mathrm{E_{VOC}}} = \frac{1}{\mathrm{ODV}} \times \frac{\partial \mathrm{ODV}}{\partial \mathrm{E_{VOC}}}$$

$$\frac{\partial^2 \log(\mathrm{ODV})}{\partial \mathrm{E_{NO_x}}\,\partial \mathrm{E_{VOC}}} = -\frac{1}{\mathrm{ODV}^2} \times \frac{\partial \mathrm{ODV}}{\partial \mathrm{E_{NO_x}}} \times \frac{\partial \mathrm{ODV}}{\partial \mathrm{E_{VOC}}} + \frac{1}{\mathrm{ODV}} \times \frac{\partial^2 \mathrm{ODV}}{\partial \mathrm{E_{NO_x}}\,\partial \mathrm{E_{VOC}}}$$

$$\frac{\partial^2 \log(\mathrm{ODV})}{\partial \mathrm{E_{NO_x}}^2} = -\frac{1}{\mathrm{ODV}^2} \times \left(\frac{\partial \mathrm{ODV}}{\partial \mathrm{E_{NO_x}}}\right)^2 + \frac{1}{\mathrm{ODV}} \times \frac{\partial^2 \mathrm{ODV}}{\partial \mathrm{E_{NO_x}}^2}$$

$$\frac{\partial \log(\mathrm{ODV})}{\partial \mathrm{E_{VOC}}^2} = -\frac{1}{\mathrm{ODV}^2} \times \left(\frac{\partial \mathrm{ODV}}{\partial \mathrm{E_{VOC}}}\right)^2 + \frac{1}{\mathrm{ODV}} \times \frac{\partial^2 \mathrm{ODV}}{\partial \mathrm{E_{VOC}}^2}$$

Appendix D: Integrated (Combined) Ozone Concentration Isopleths of CMAQ-HDDM Using the Square-root Inverse Distance Weighted (SRIDW) Method and the Isopleths Based on Each Individual Simulation

In this section, we conducted a set of 15 CMAQ-HDDM simulations with different emission levels (Fig. 3.1; Table 3.1). Eleven of the cases were used to develop ozone isopleth diagrams. Isopleths were generated for each of 10 cases (Table 3.1, marked with *), individually based on the simulated ozone levels and the first- and second-order sensitivities with Taylor series expansion (as described by Hakami et al., (2004)). The 10 isopleths were then blended using distance-based (in emissions space) square root inverse distance weighting (SRIDW). We show the combined isopleth and all individual isopleths using CMAQ-HDDM simulations under different emissions levels for each individual monitoring site.

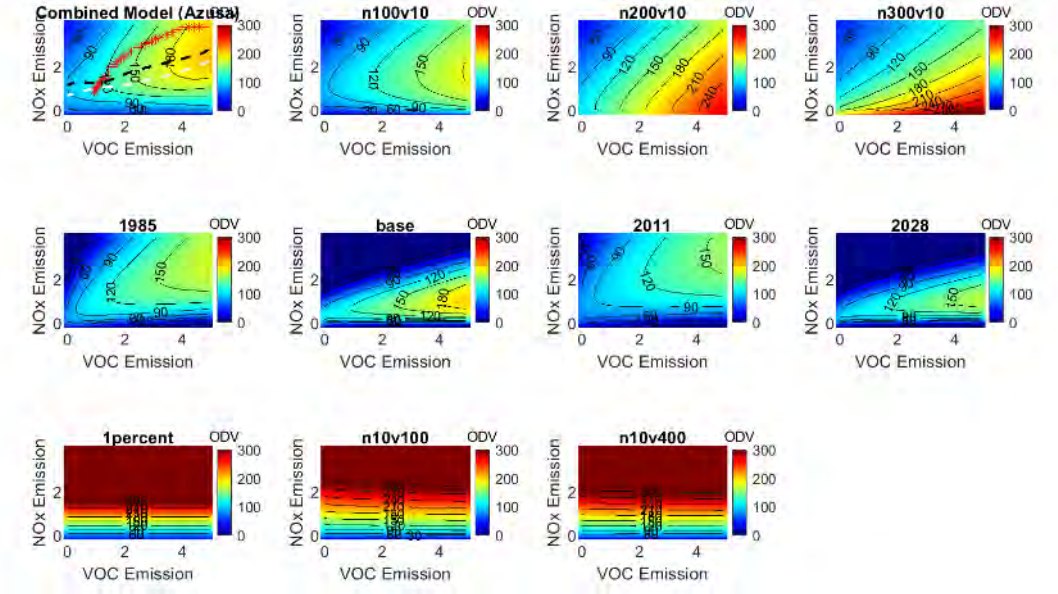
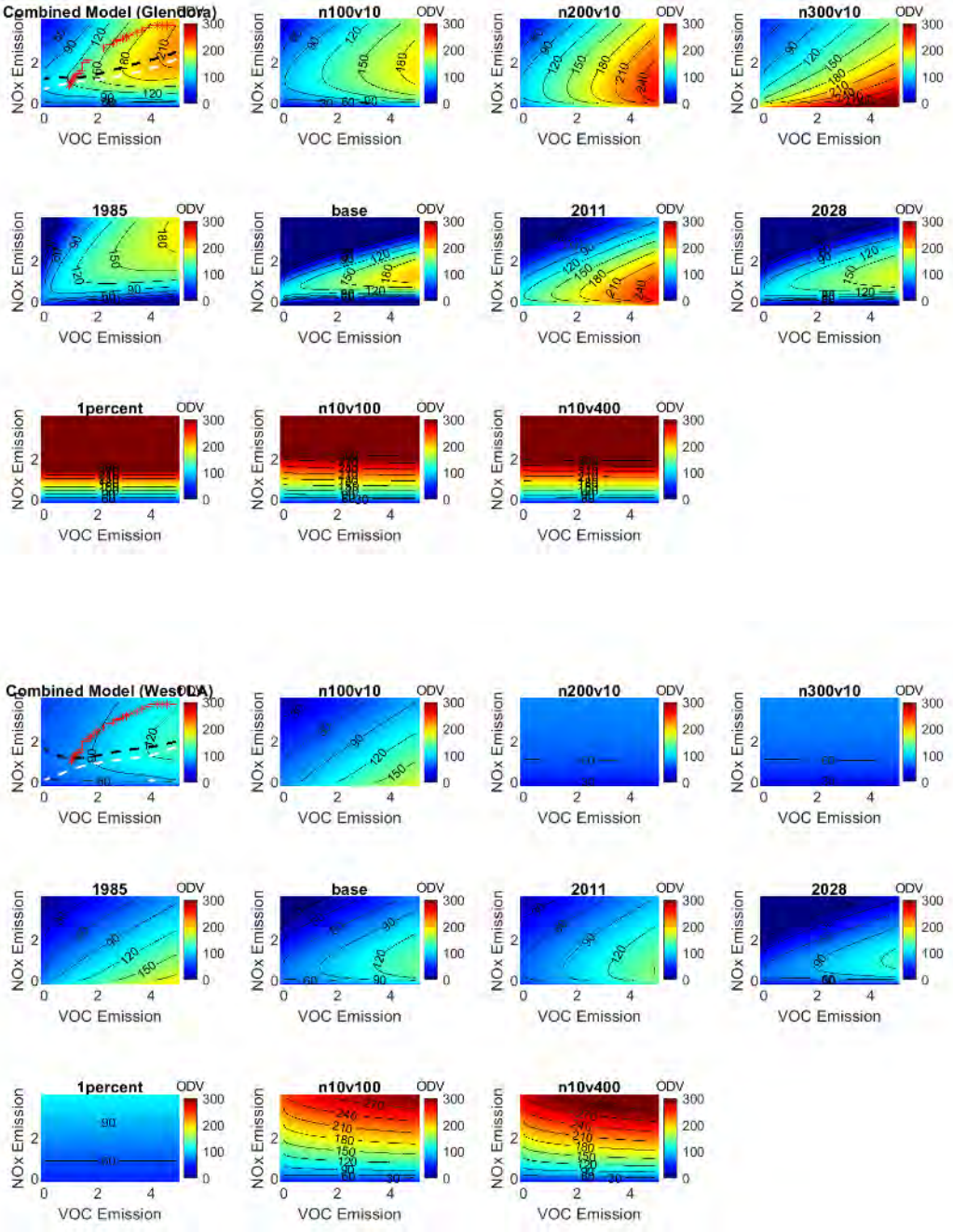
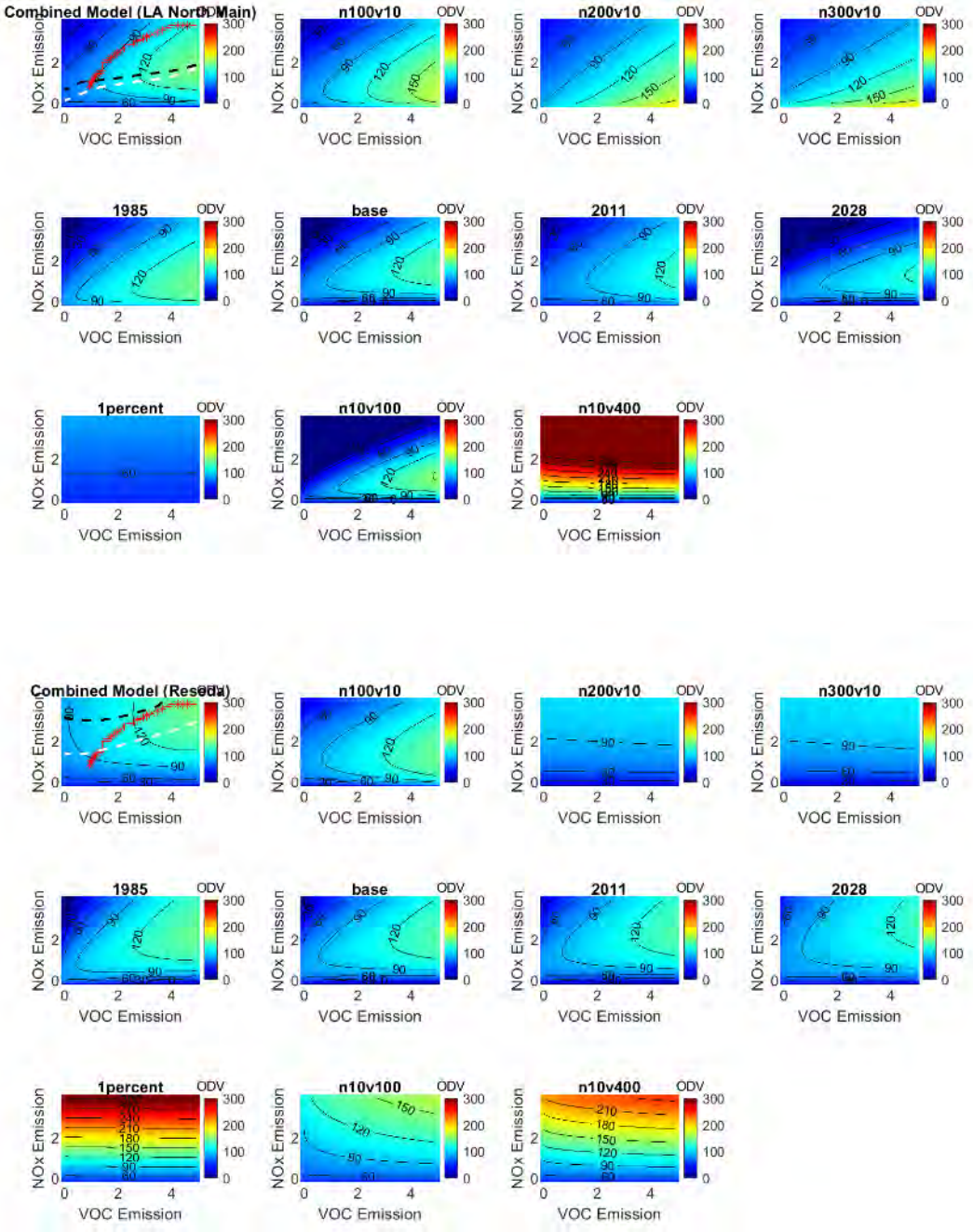
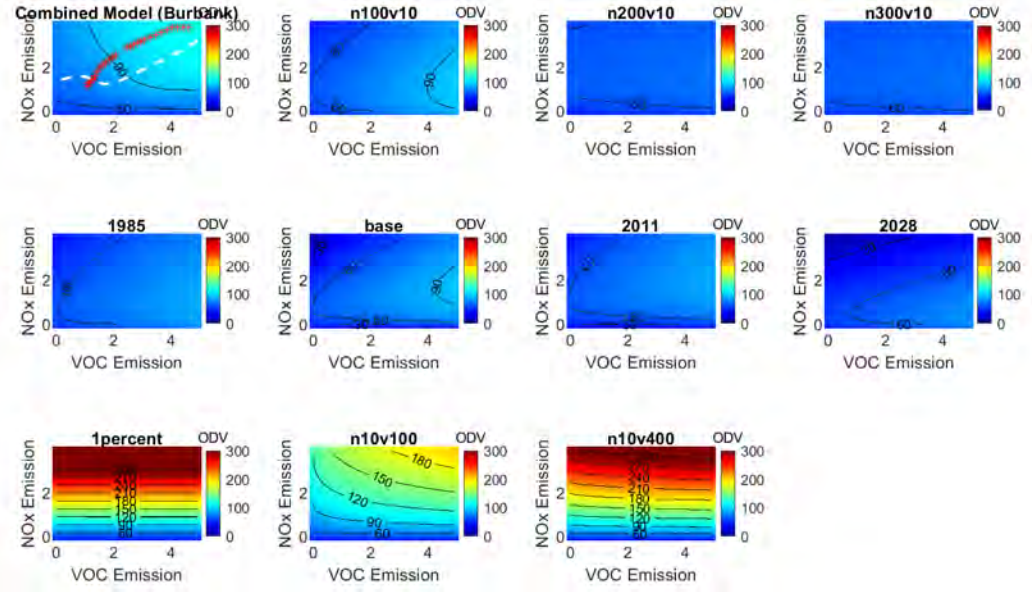
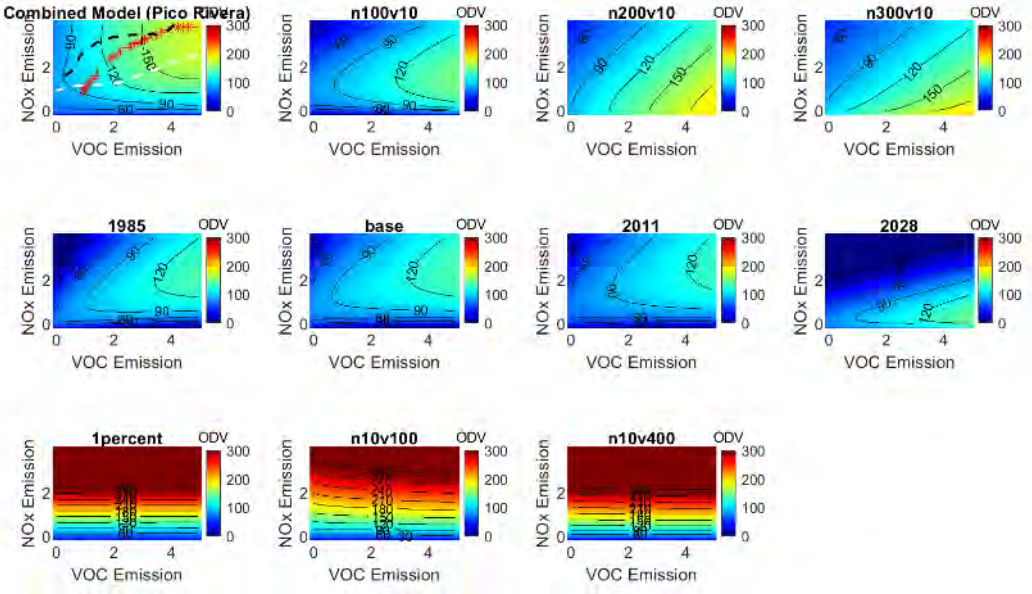


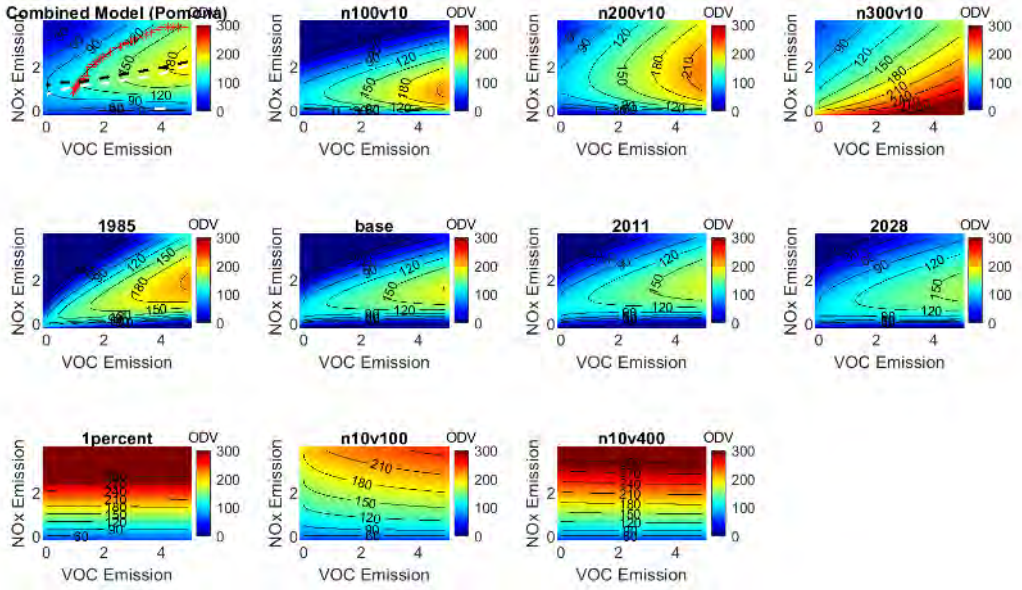
Figure D.1 The CMAQ-HDDM-based ozone-emissions isopleths for Azusa, including the combined isopleth and all 10 individual isopleths under different emissions scenarios used to build the combined isopleth. In the combined isopleth, the black dashed line indicates the zero ozone-to-NOx emissions sensitivity line. White dashed line indicates the equal ozone-to-NOx and VOC emissions sensitivity line. Red asterisks indicate historical NOx and VOC emissions trajectories. The name of each sub-plot indicates the emissions level used to conduct the CMAQ-HDDM simulation, which then used to build the combined isopleth (upper-left). Results for other sites shown below in this section follow the same layout.

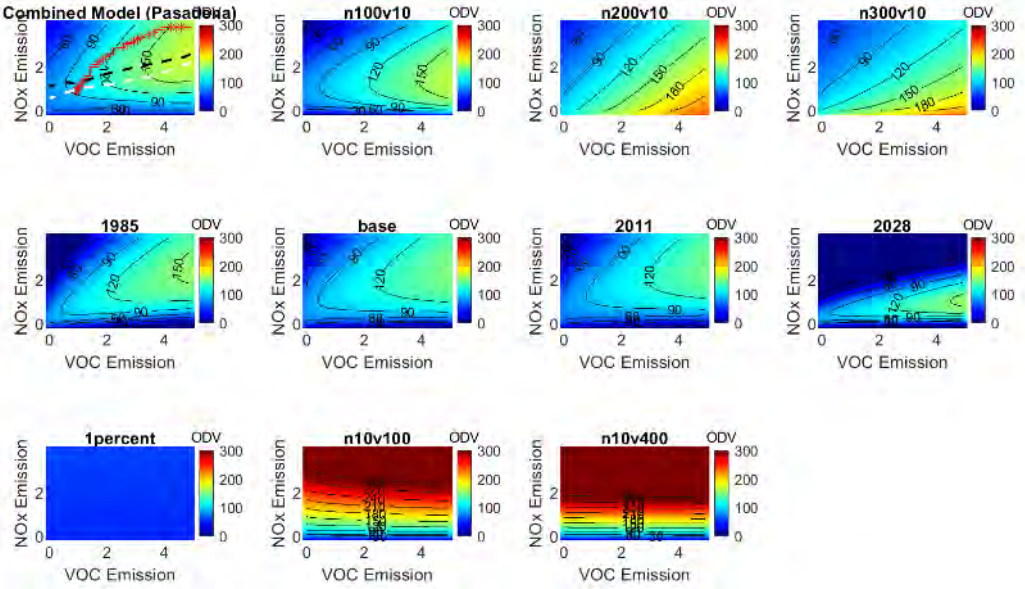

Combined Model (Glendora)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
Combined Model (West LA)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

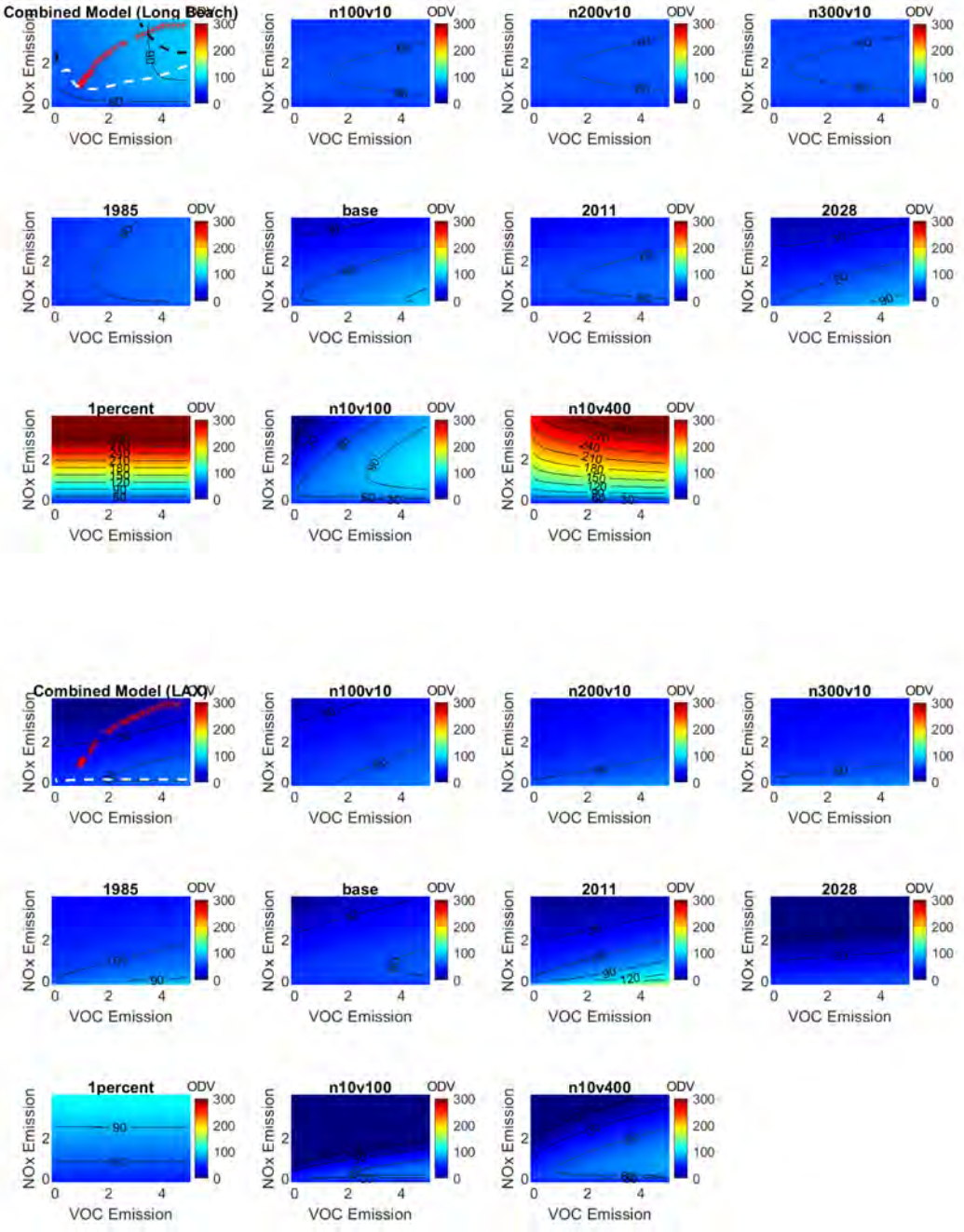

Combined Model (LA North Main)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
Combined Model (Reseda)
NOx Emission
VOC Emission
ODV

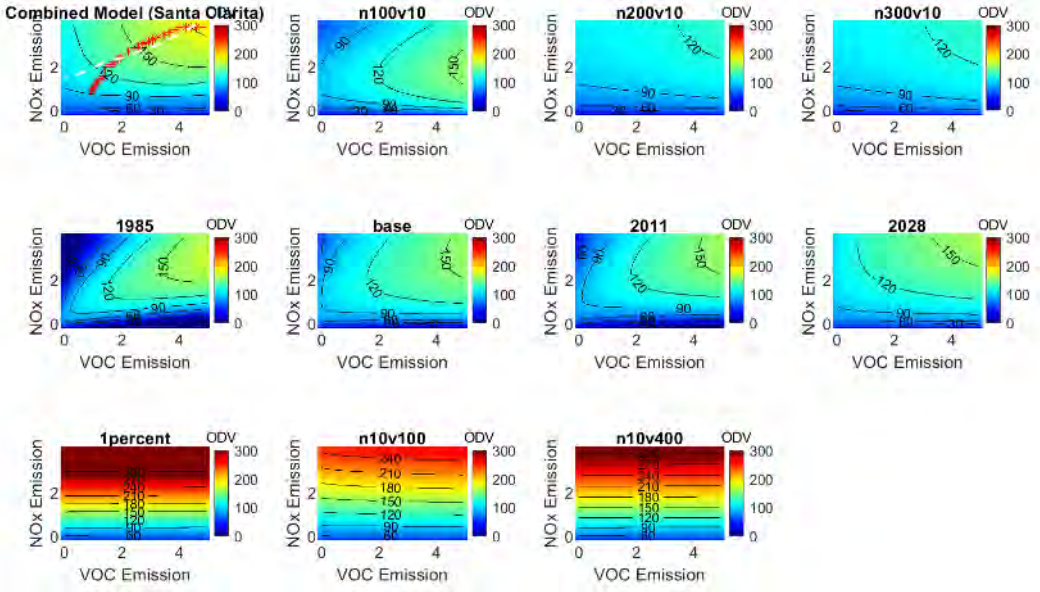

Combined Model (Burbank)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

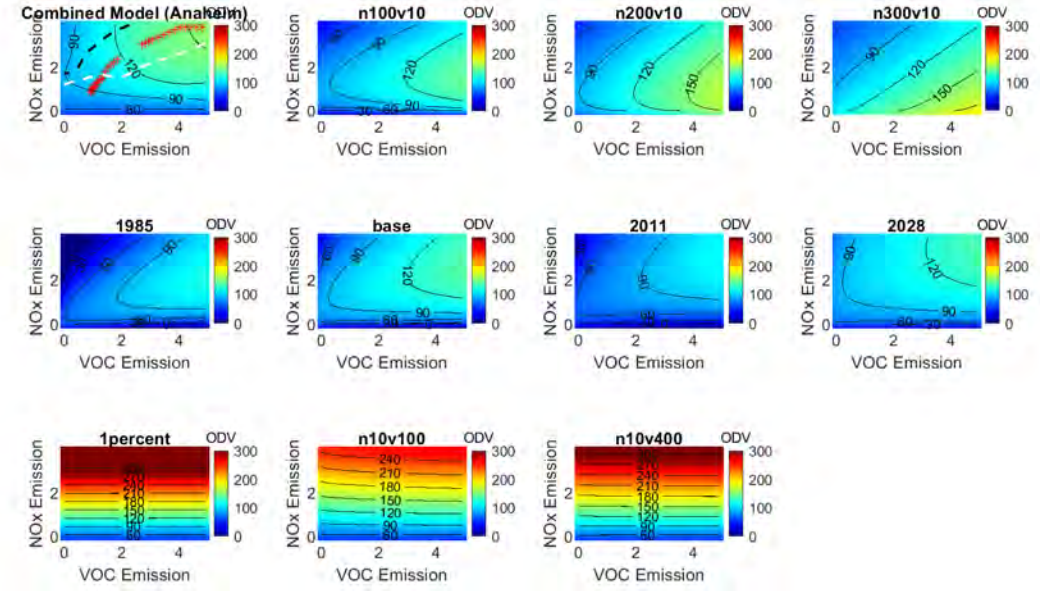

Combined Model (Pico Rivera)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

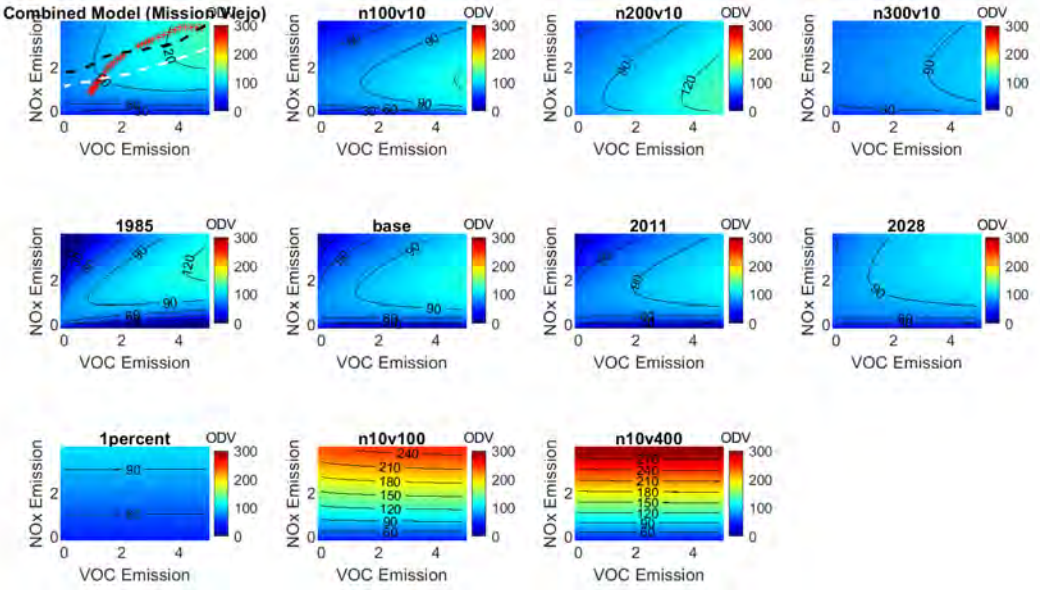

Combined Model (Pomona)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

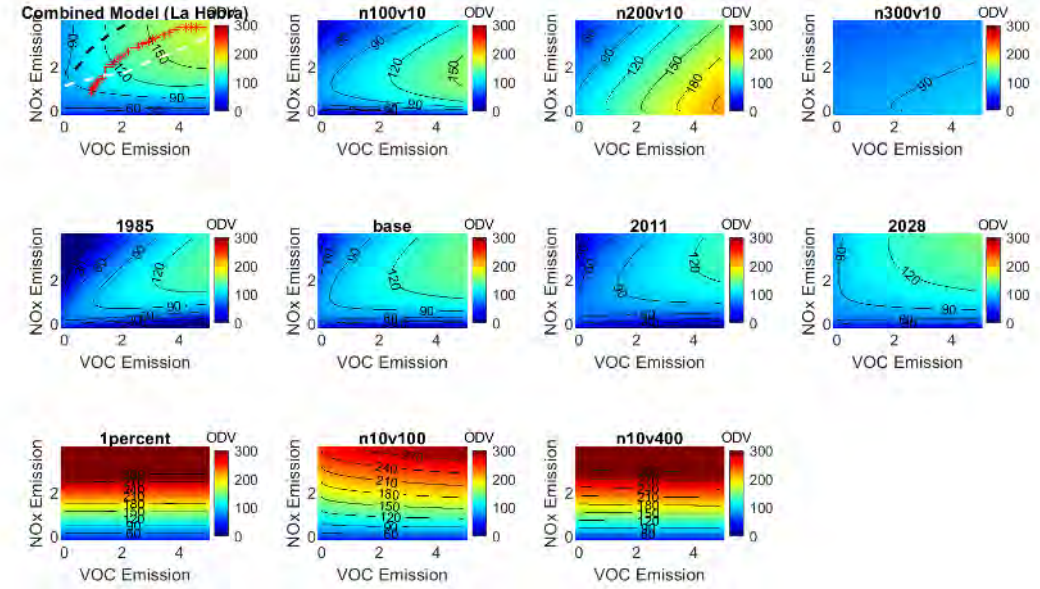

Combined Model (Pasadena)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

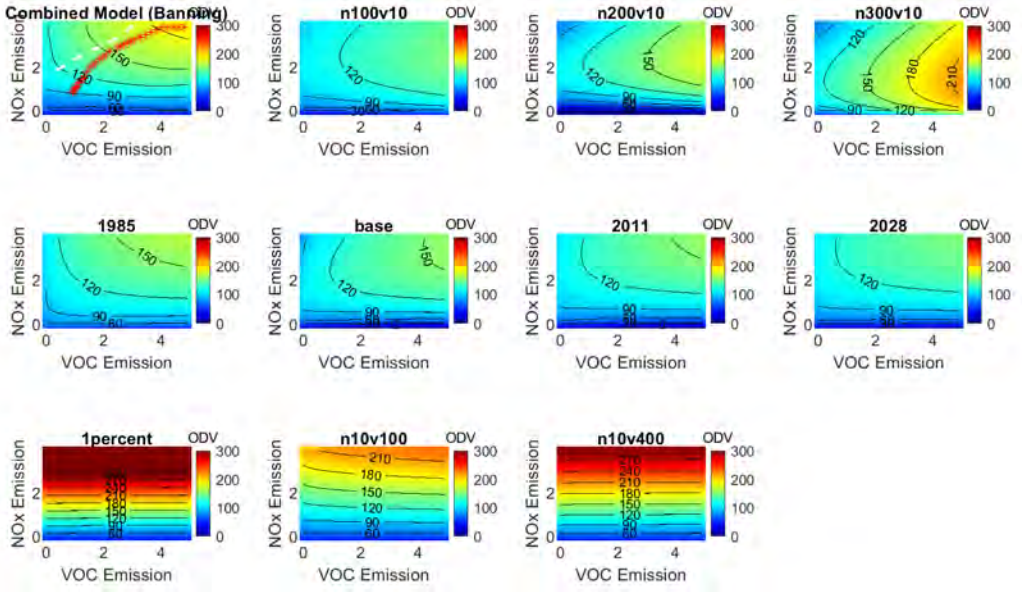

Combined Model (Long Beach)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
Combined Model (LAX)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

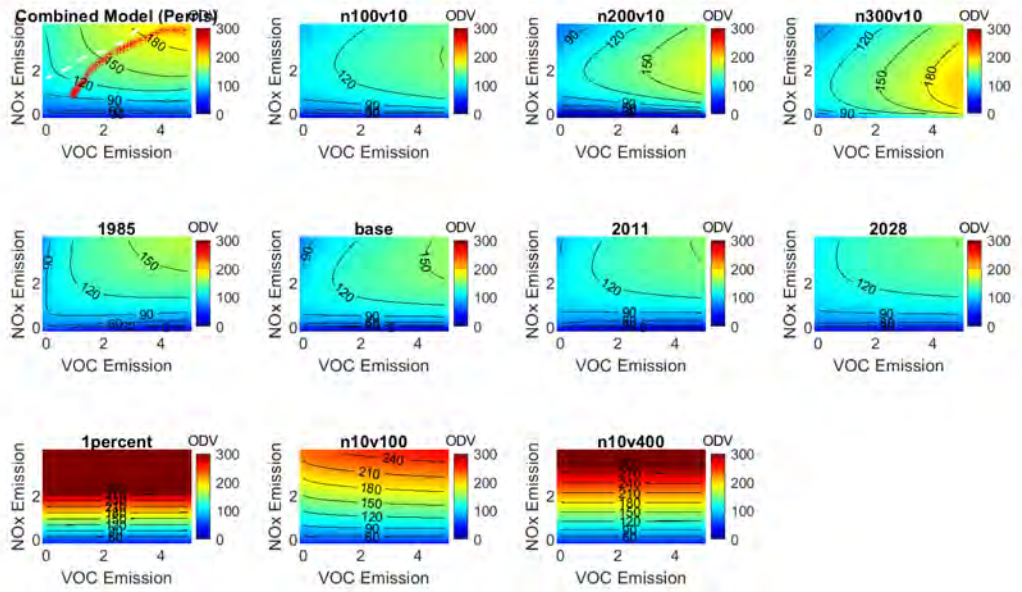

Combined Model (Santa Clarita)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

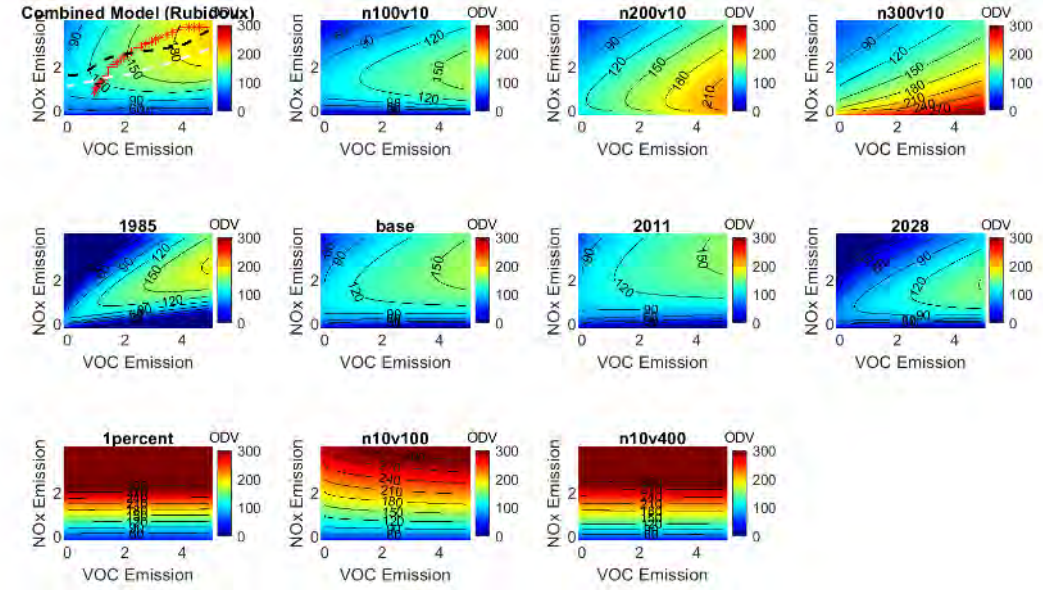

Combined Model (Anaheim)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

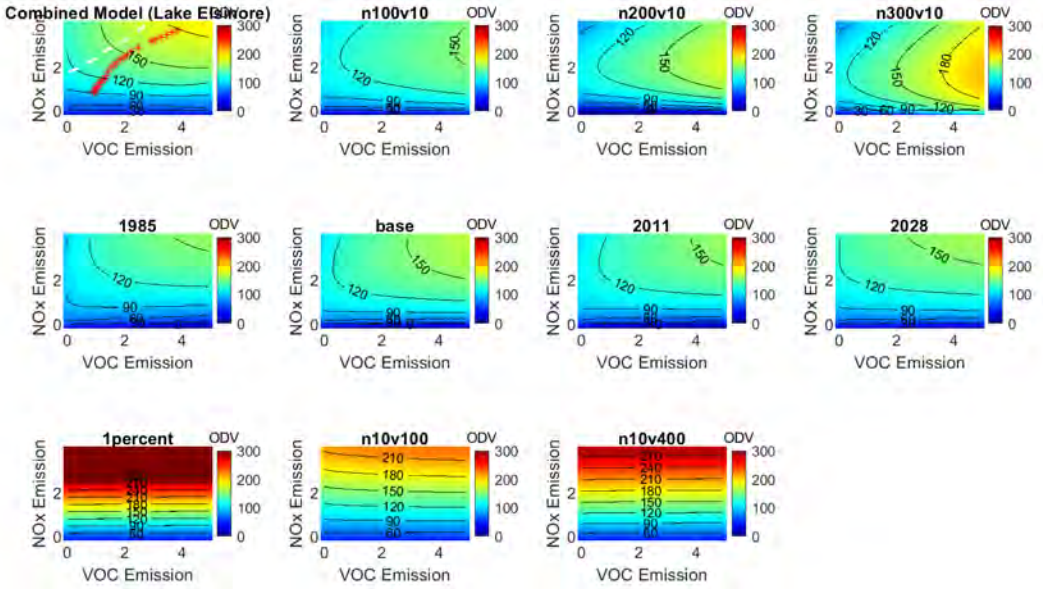

Combined Model (Mission Viejo)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

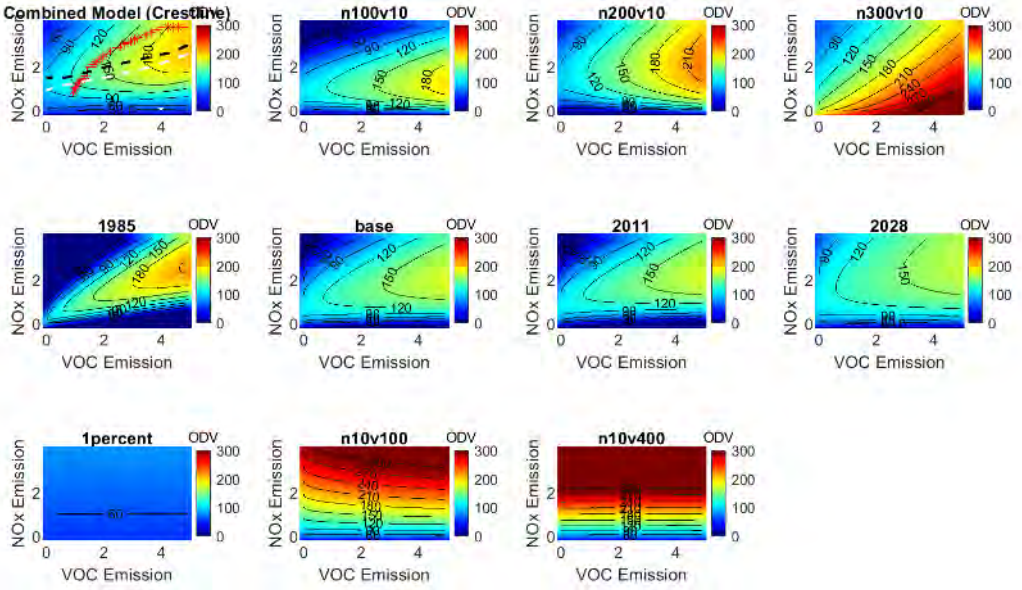

Combined Model (La Habra)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

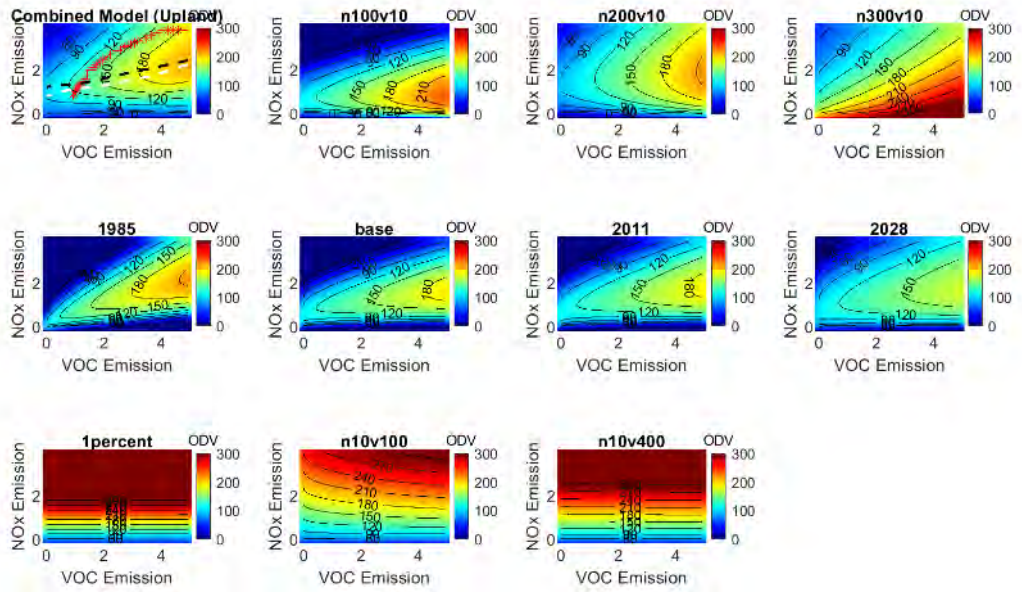

Combined Model (Bandung)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

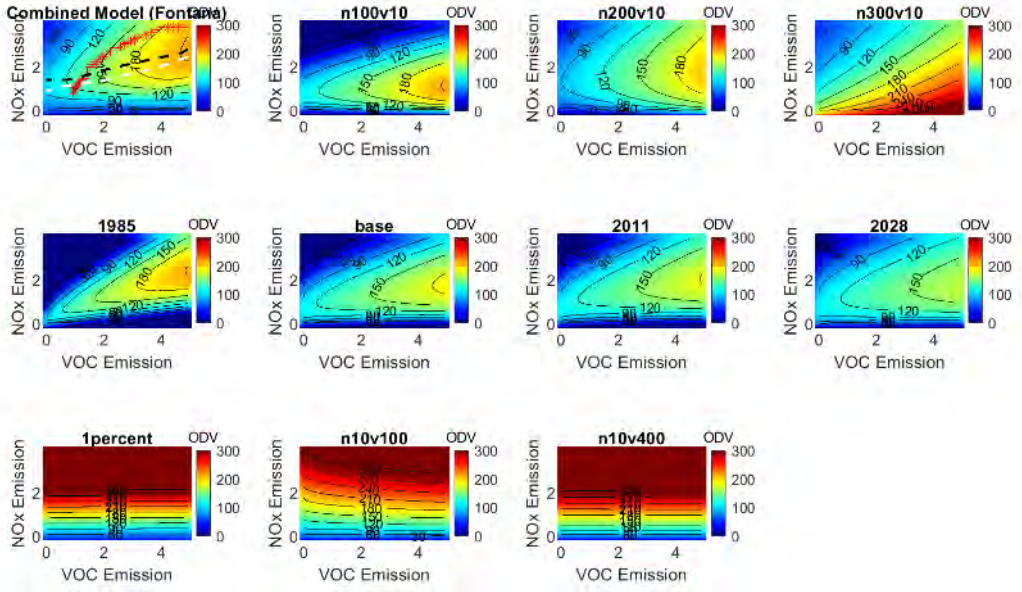

Combined Model (Perth)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV

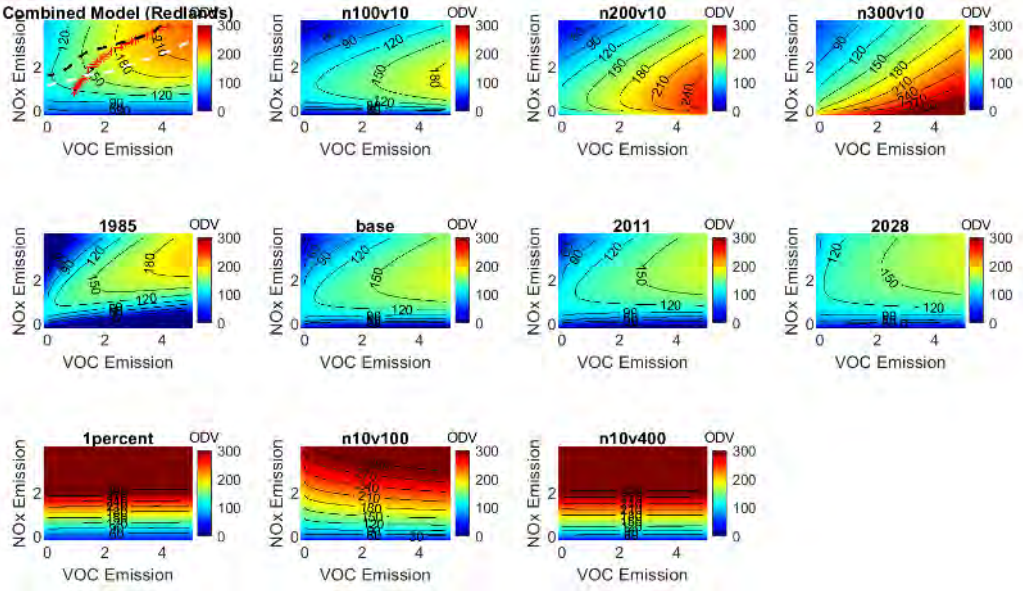

Combined Model (Rubidoux)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
ODV
NOx Emission
VOC Emission

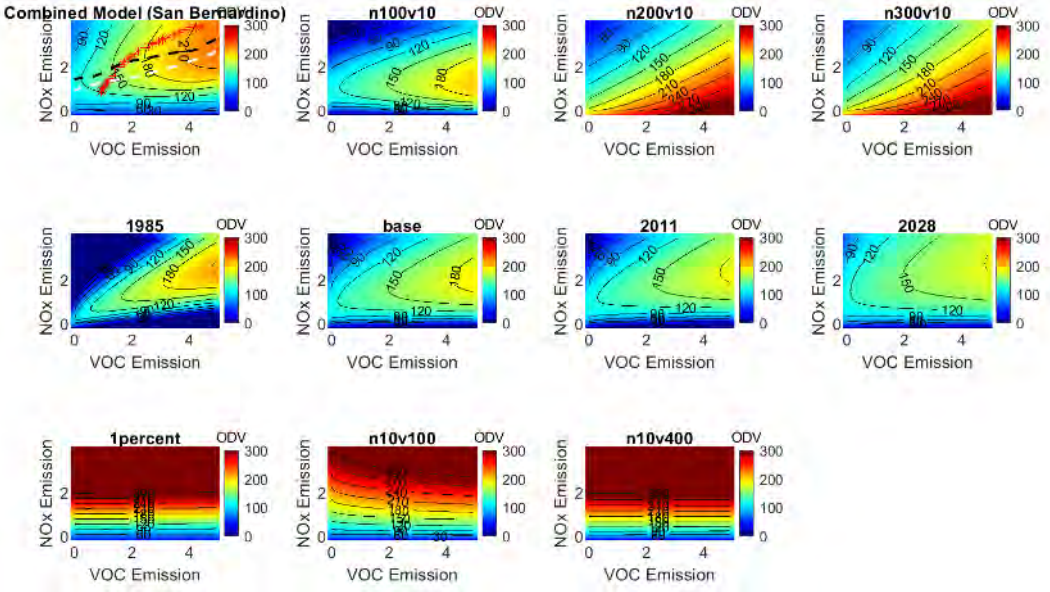

Combined Model (Lake Elsinore)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
ODV
NOx Emission
VOC Emission


Combined Model (Crestline)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV


Combined Model (Upland)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
NOx Emission
VOC Emission
ODV


Combined Model (Fontana)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
ODV
NOx Emission
VOC Emission


Combined Model (Redlands)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
ODV
NOx Emission
VOC Emission


Combined Model (San Bernardino)
n100v10
n200v10
n300v10
1985
base
2011
2028
1percent
n10v100
n10v400
ODV
NOx Emission
VOC Emission

Appendix E: Integrated (combined) Ozone Concentration and Sensitivity Isopleths of CMAQ-HDDM Quadratic Fitting Method and the Comparison between Base Quadratic and Log Quadratic Model

To develop ozone isopleths utilizing ozone concentrations and sensitivities derived from CMAQ-DDM, we developed quadratic and log quadratic forms using least squares fitting. We show ozone and sensitivities isopleths developed based on the base quadratic and log quadratic fitting methods and the comparison between the two methods for each individual monitoring site.

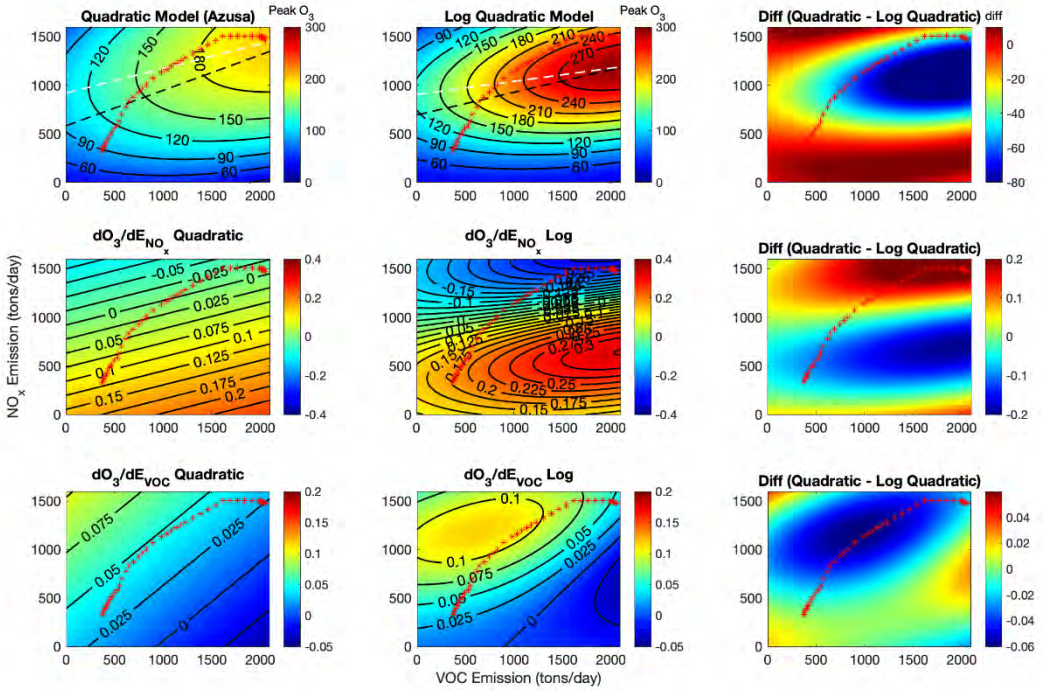
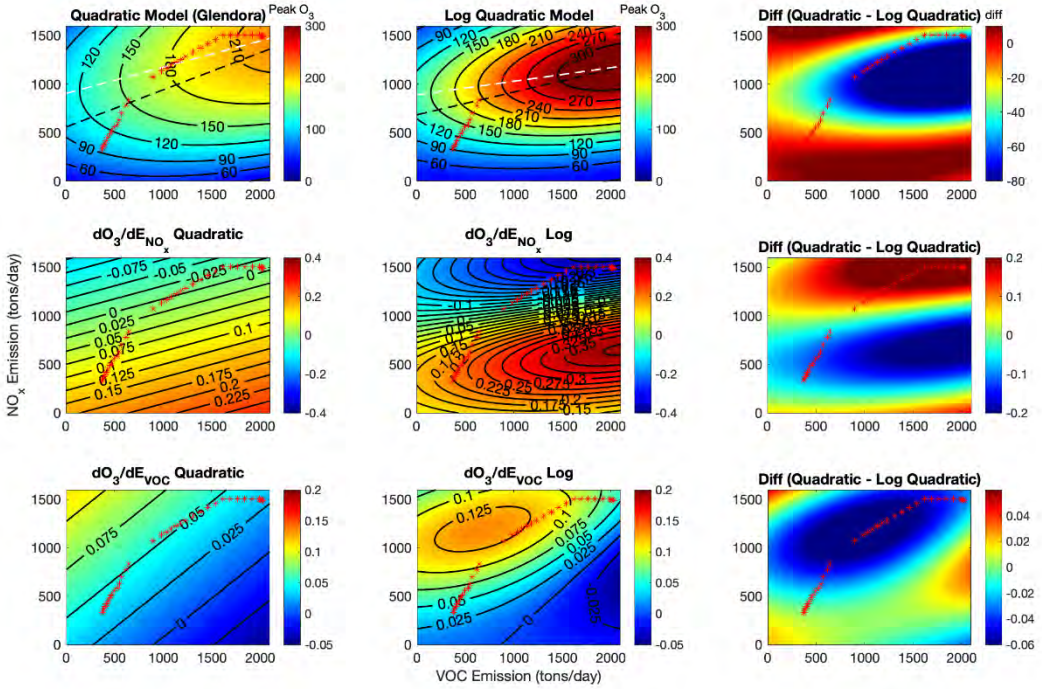
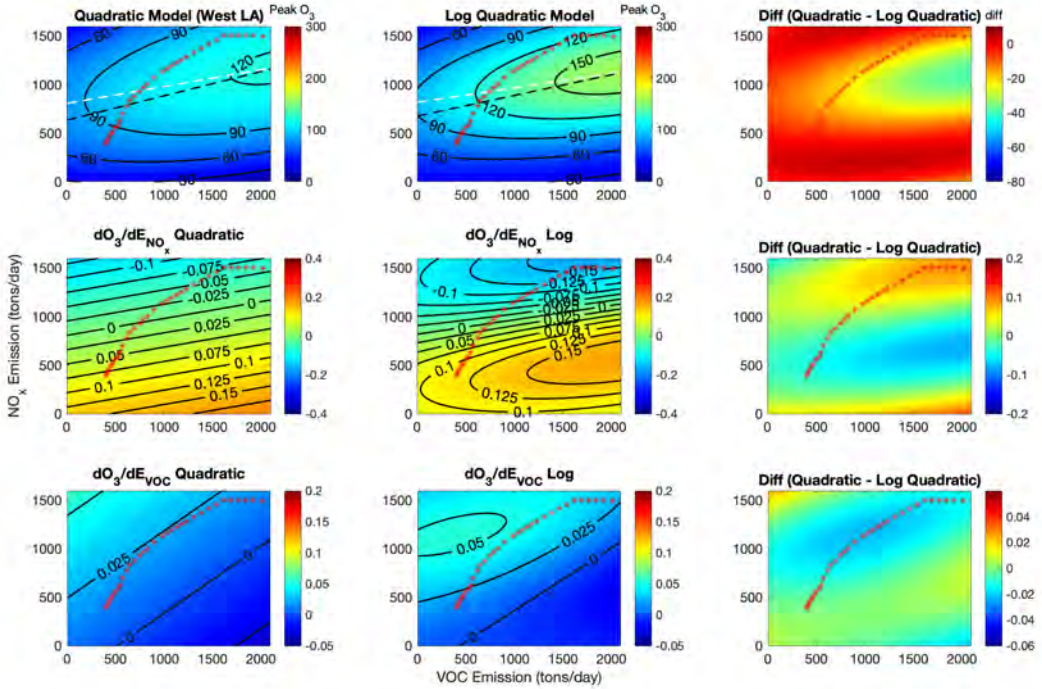
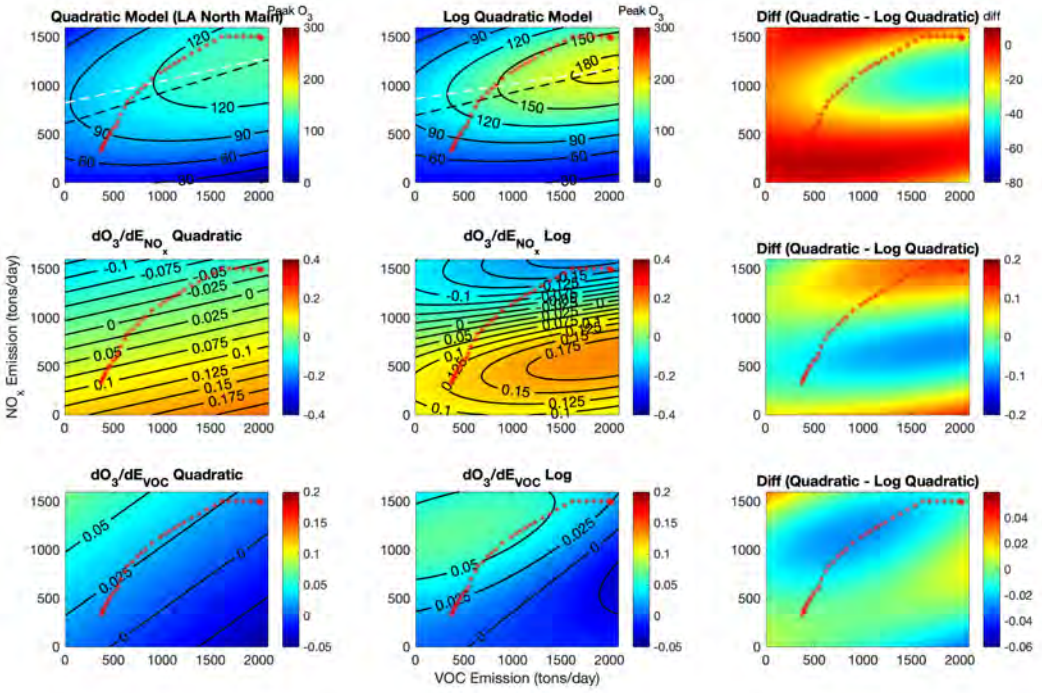
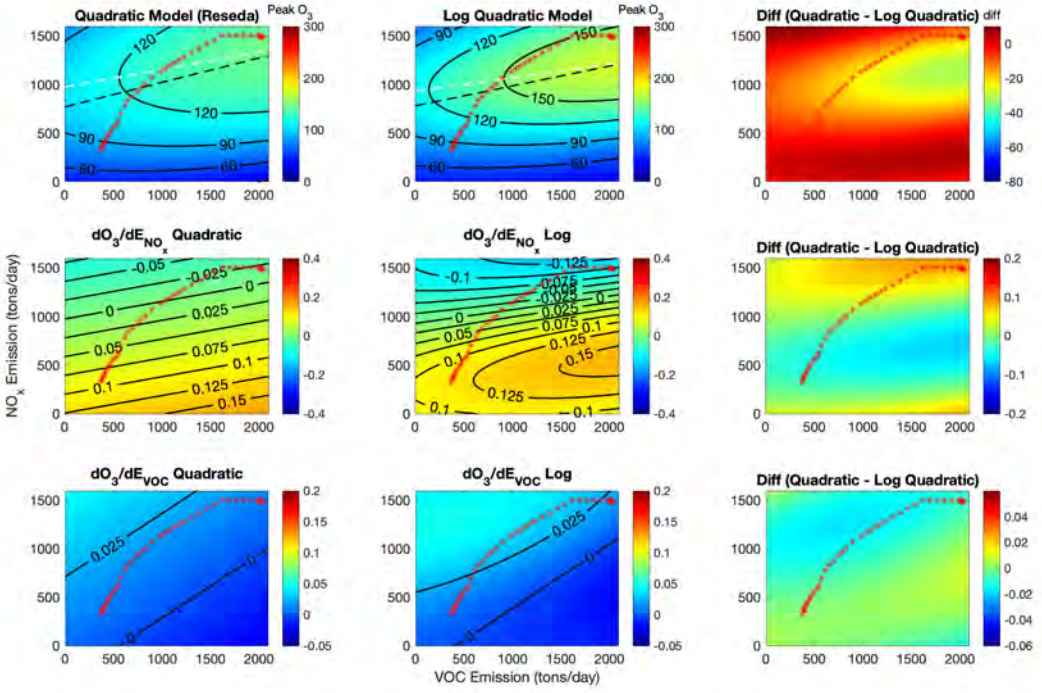


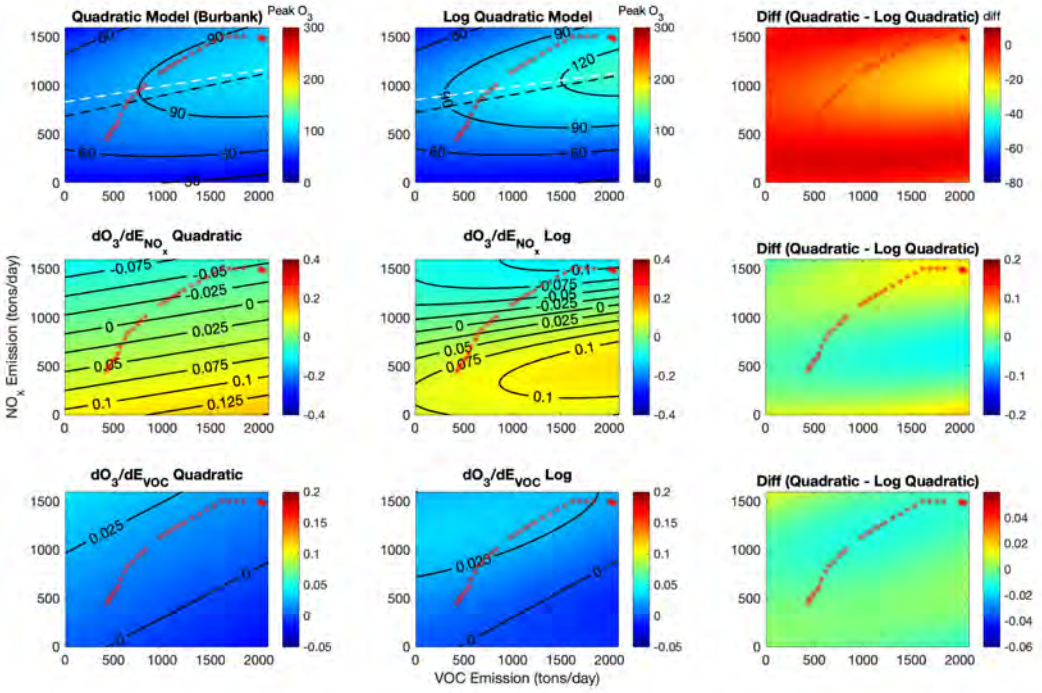
Figure E.1 The quadratic-fitting method-based ozone-emissions concentrations and sensitivity isopleth based on both base and log model, and the comparison between models for Azusa. The first column shows the base model-derived isopleths. The second column shows the log model-derived isopleths. The third column shows the difference between those two. The first row shows the ozone concentration isopleths; the second row shows the ozone-to-NOx emissions sensitivity isopleths; and the third row shows the ozone-to-VOC emissions sensitivity isopleths. The white dash line indicates the zero-NOx-sensitivity line, and the black dash line indicates the equal-NOx-VOC sensitivity line. Results for other sites shown below in this section follow the same layout.

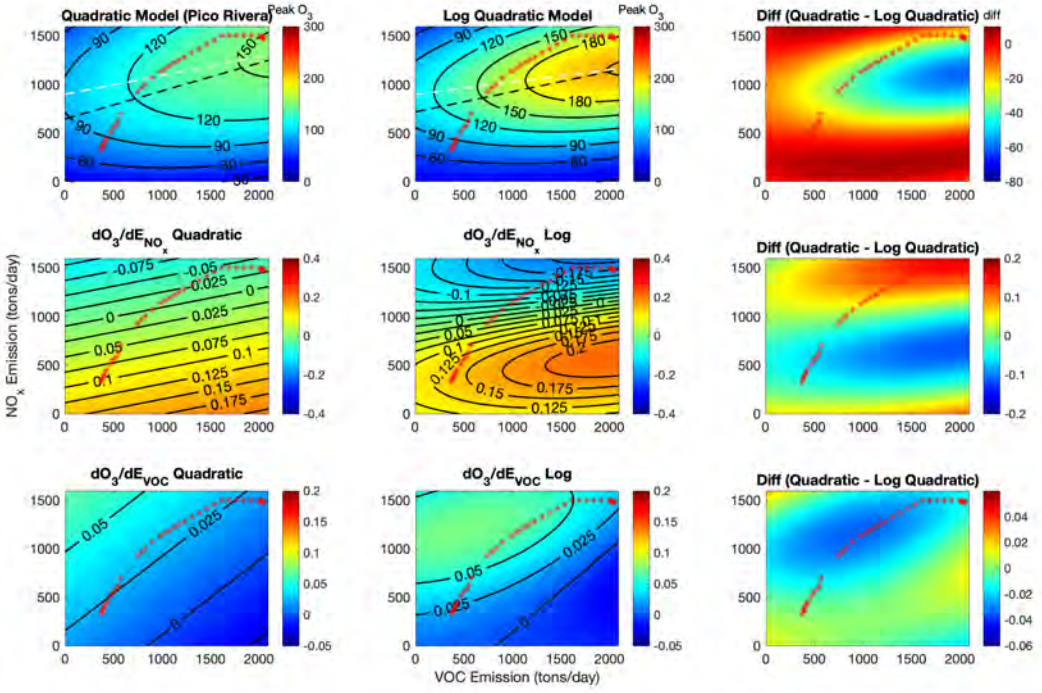

Quadratic Model (Glendora)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

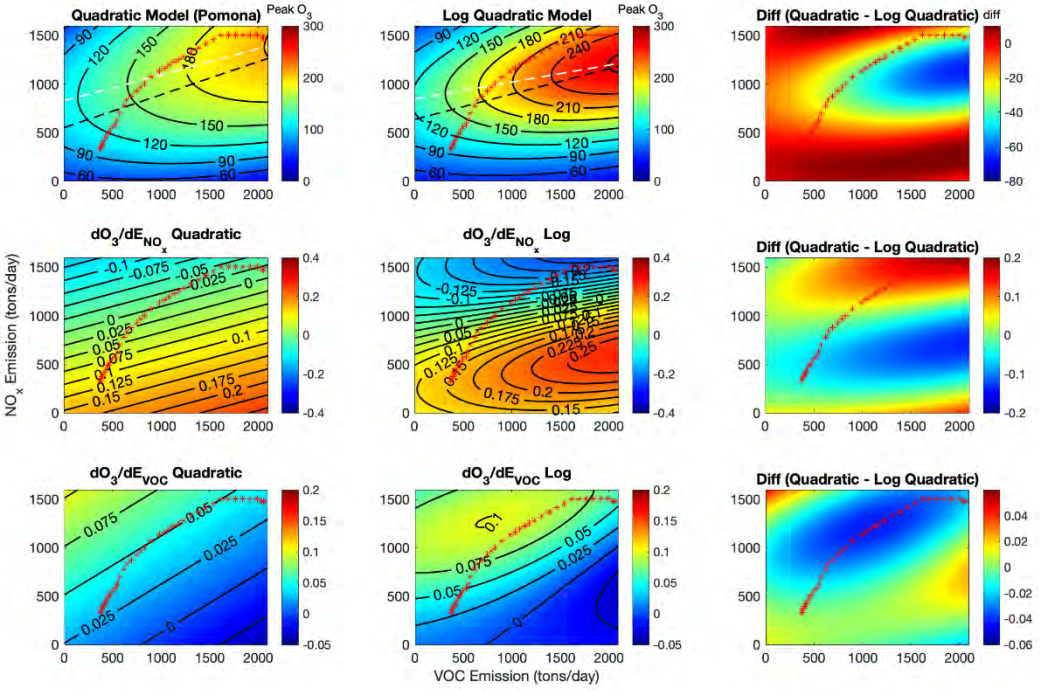

Quadratic Model (West LA)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

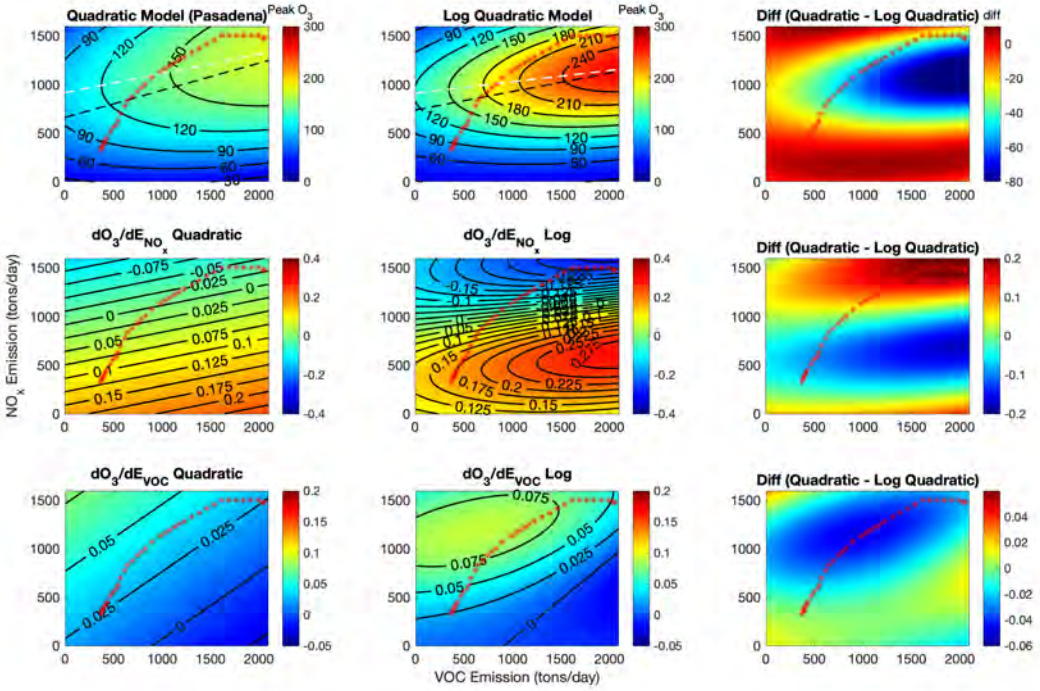

Quadratic Model (LA North Main)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

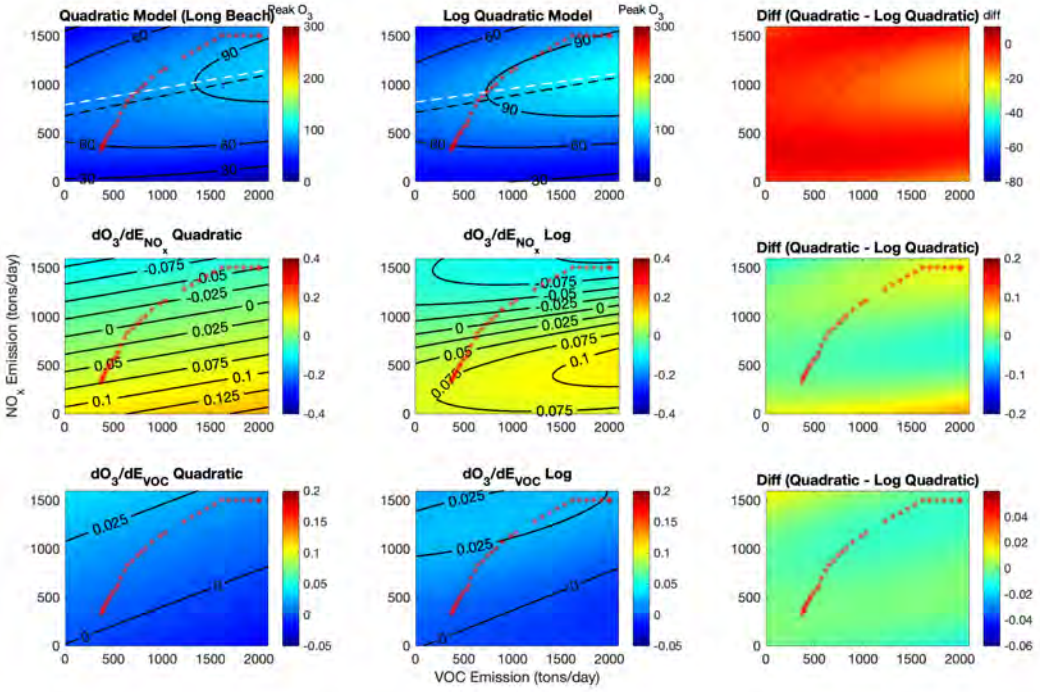

Quadratic Model (Reseda)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

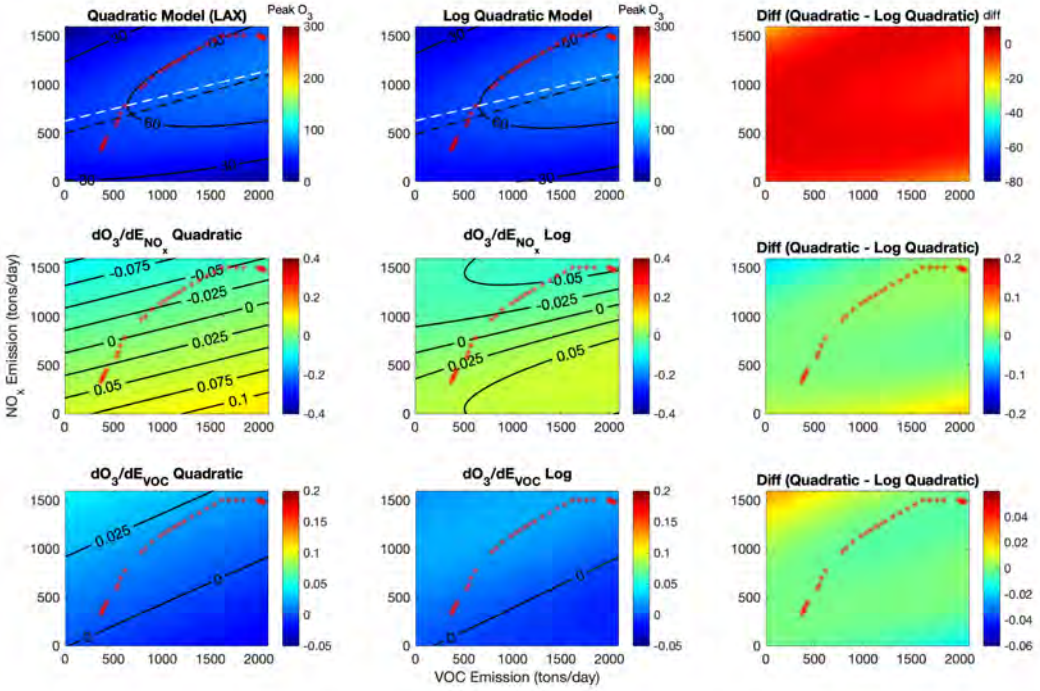

Quadratic Model (Burbank)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

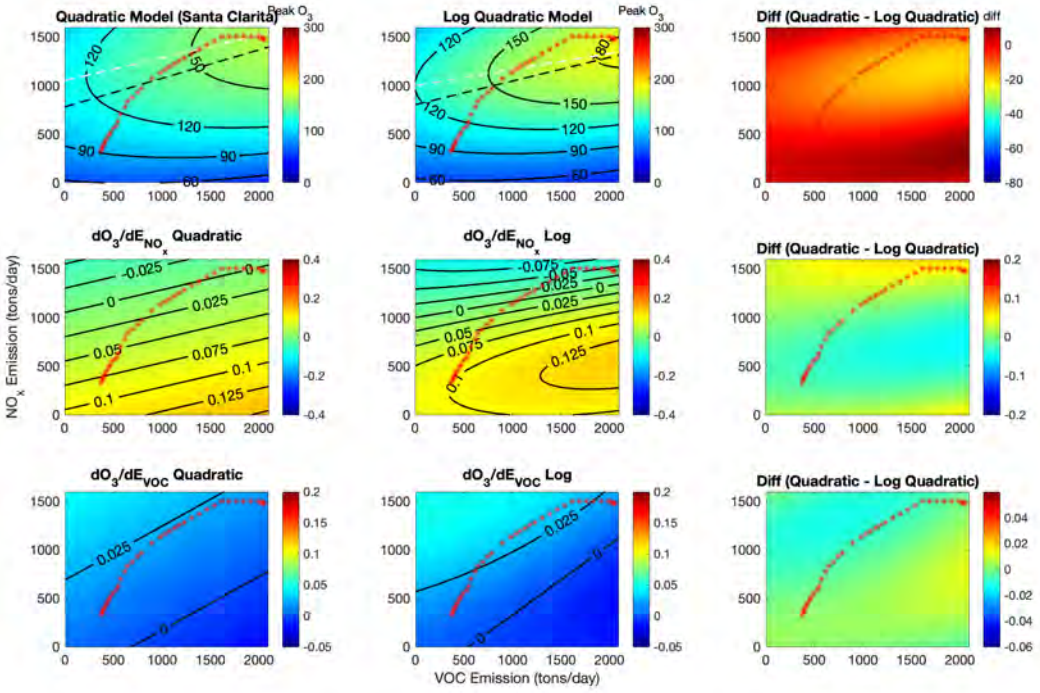

Quadratic Model (Pico Rivera)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

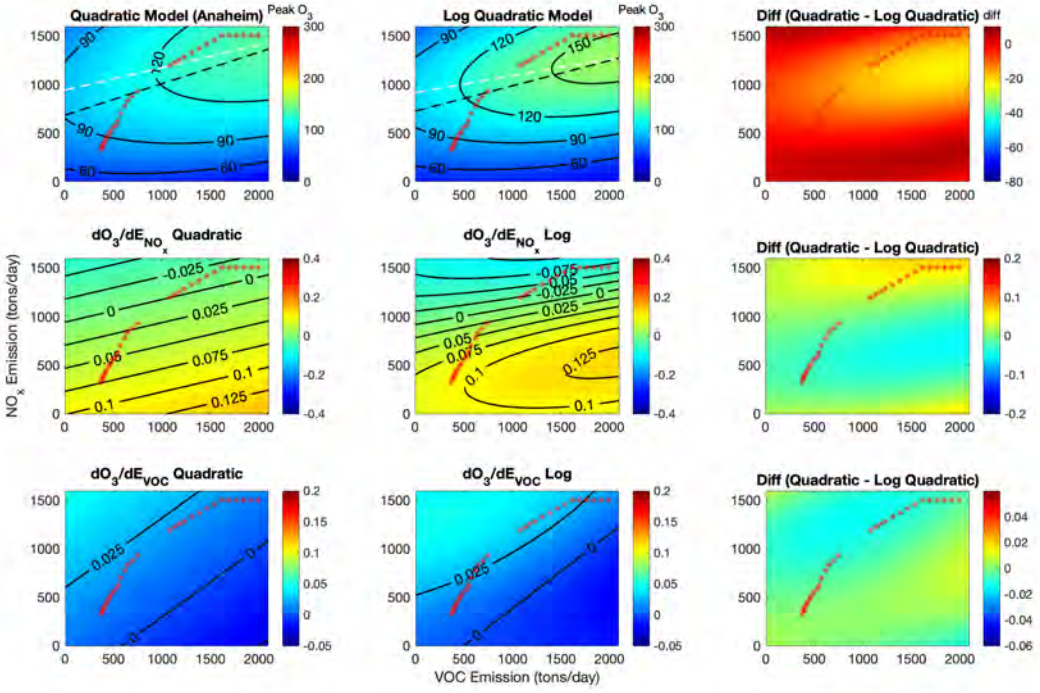

Quadratic Model (Pomona)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

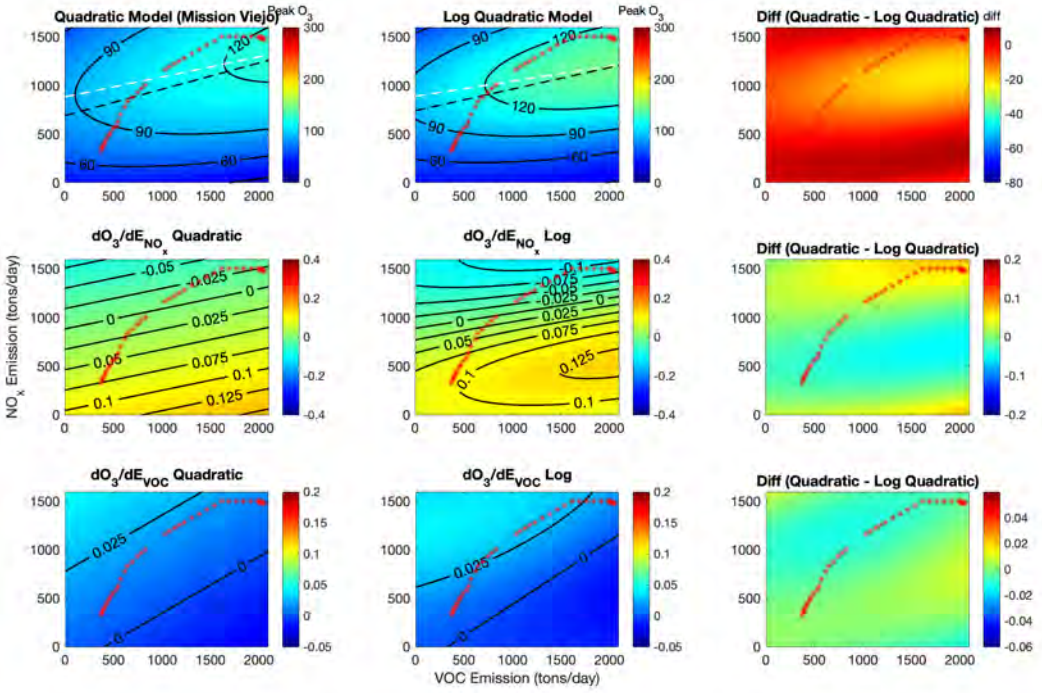

Quadratic Model (Pasadena)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

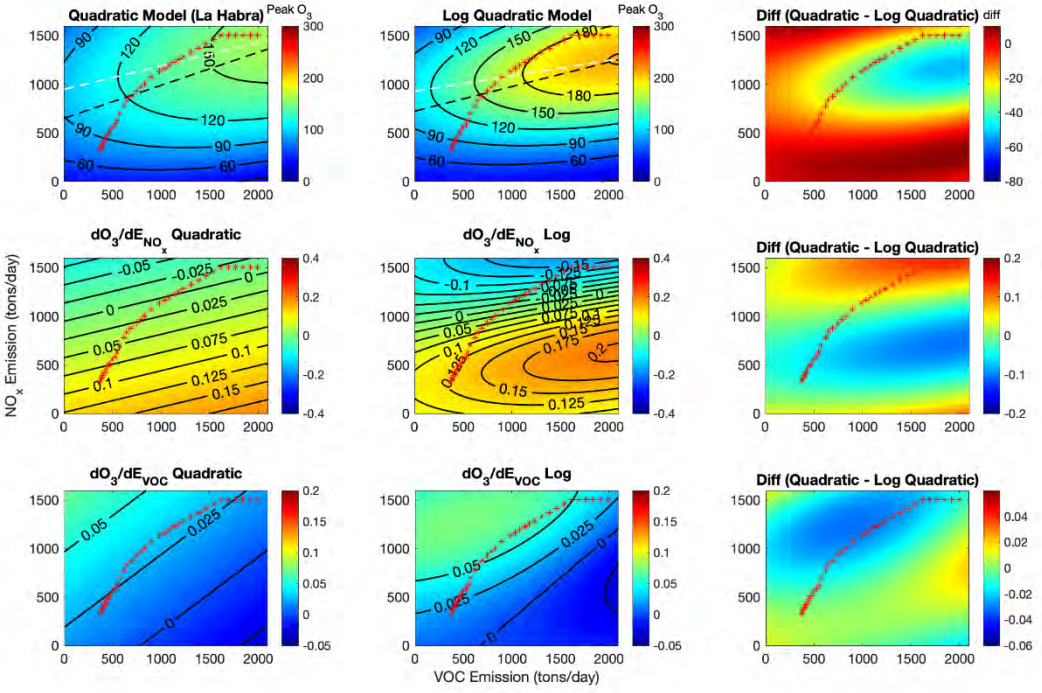

Quadratic Model (Long Beach)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

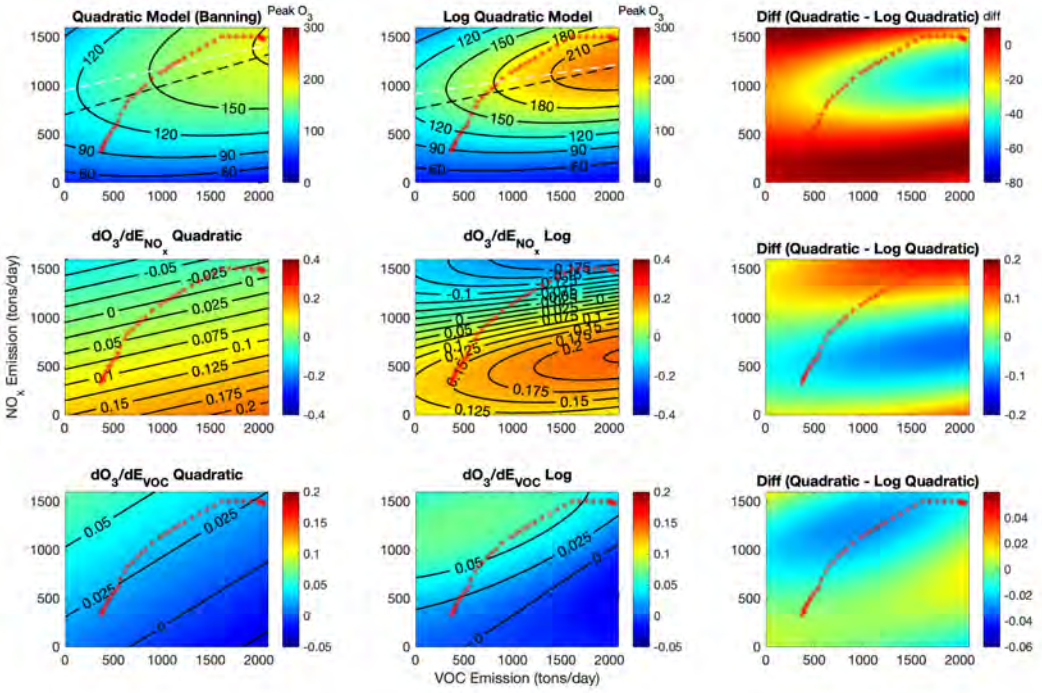

Quadratic Model (LAX)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

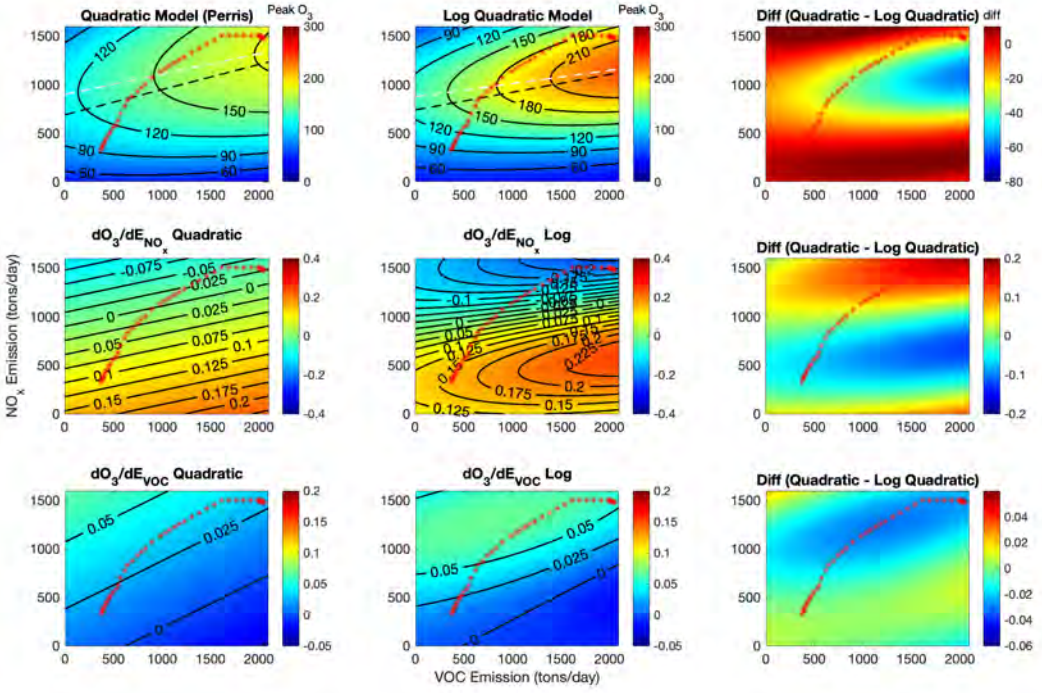

Quadratic Model (Santa Clarita)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

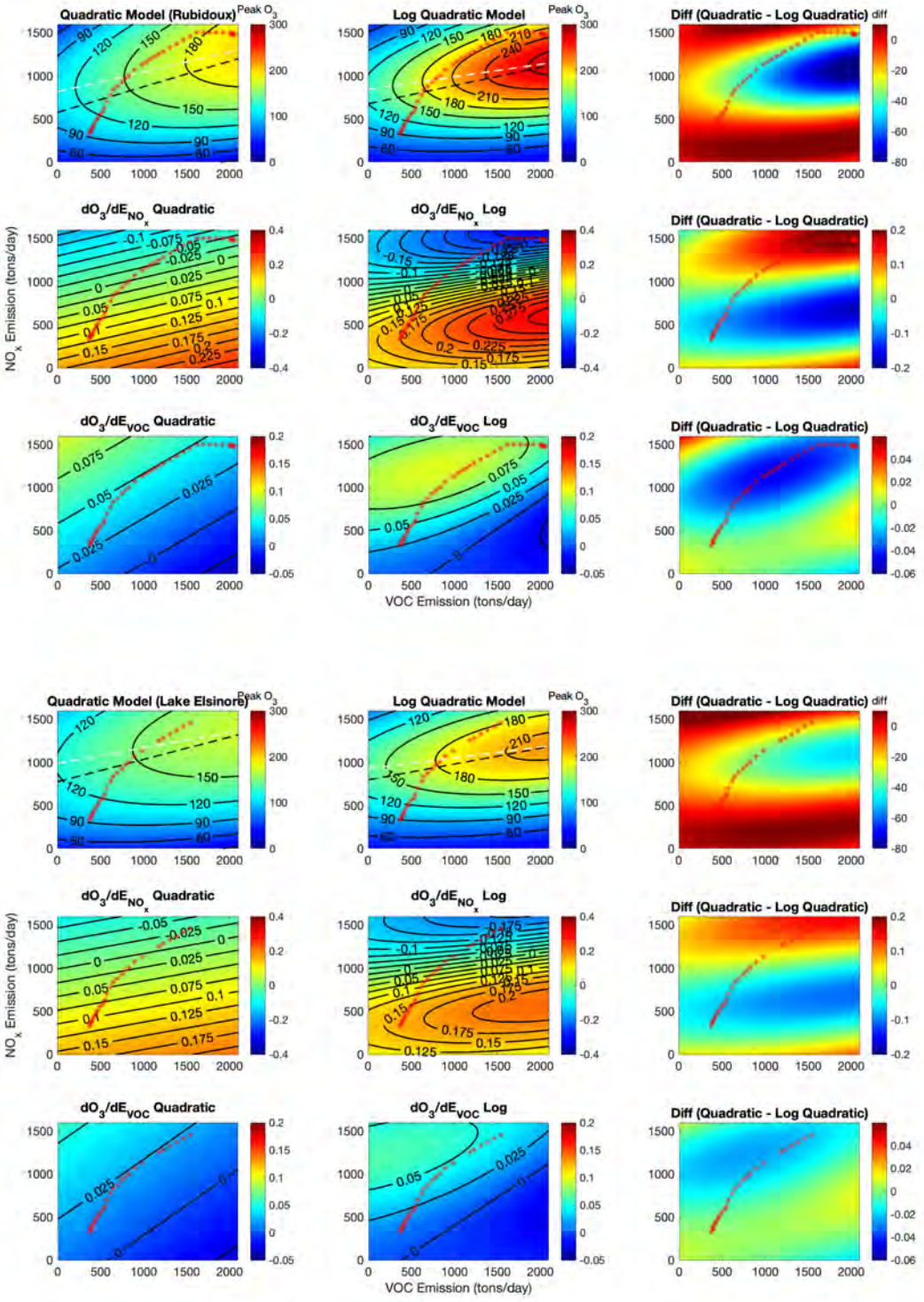

Quadratic Model (Anaheim)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

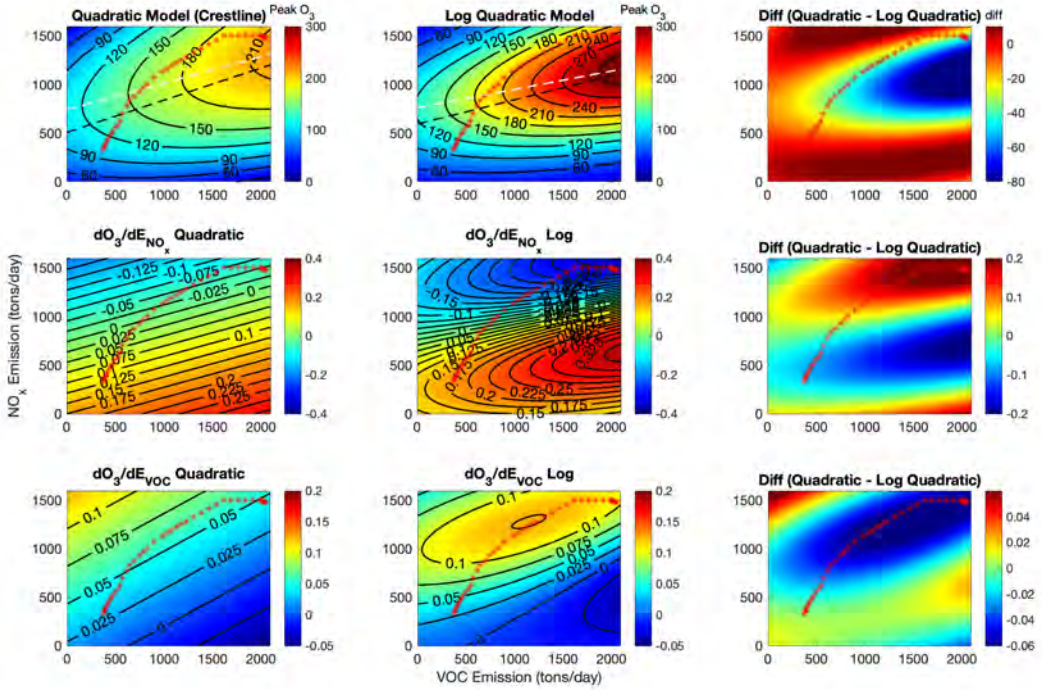

Quadratic Model (Mission Viejo)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
VOC Emission (tons/day)

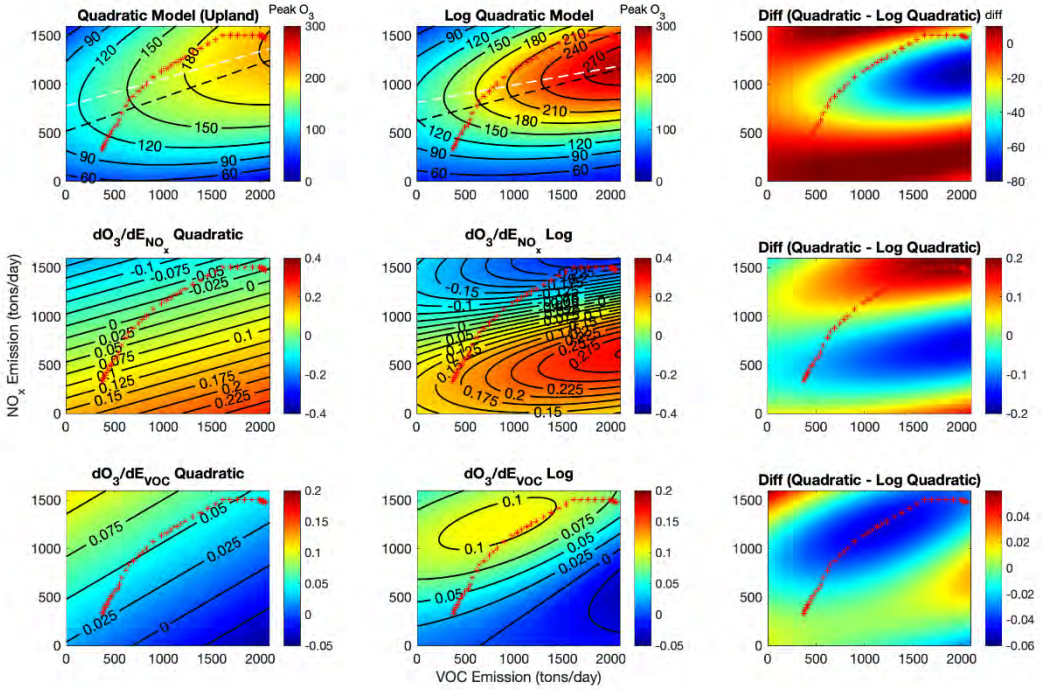

Quadratic Model (La Habra)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
VOC Emission (tons/day)

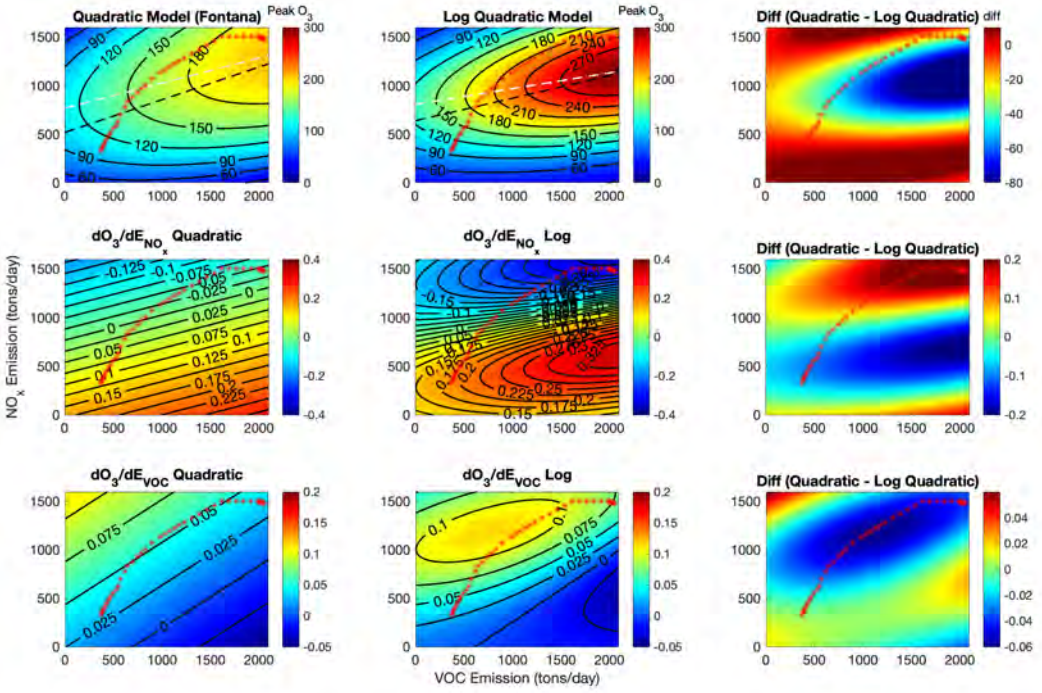

Quadratic Model (Banning)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

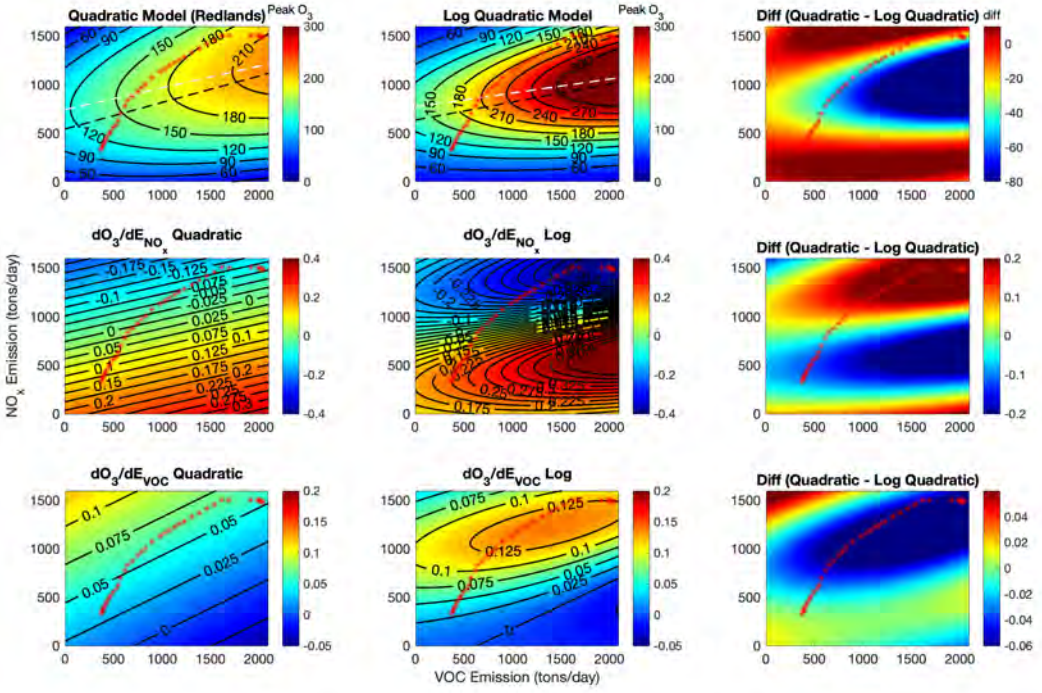

Quadratic Model (Perris)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

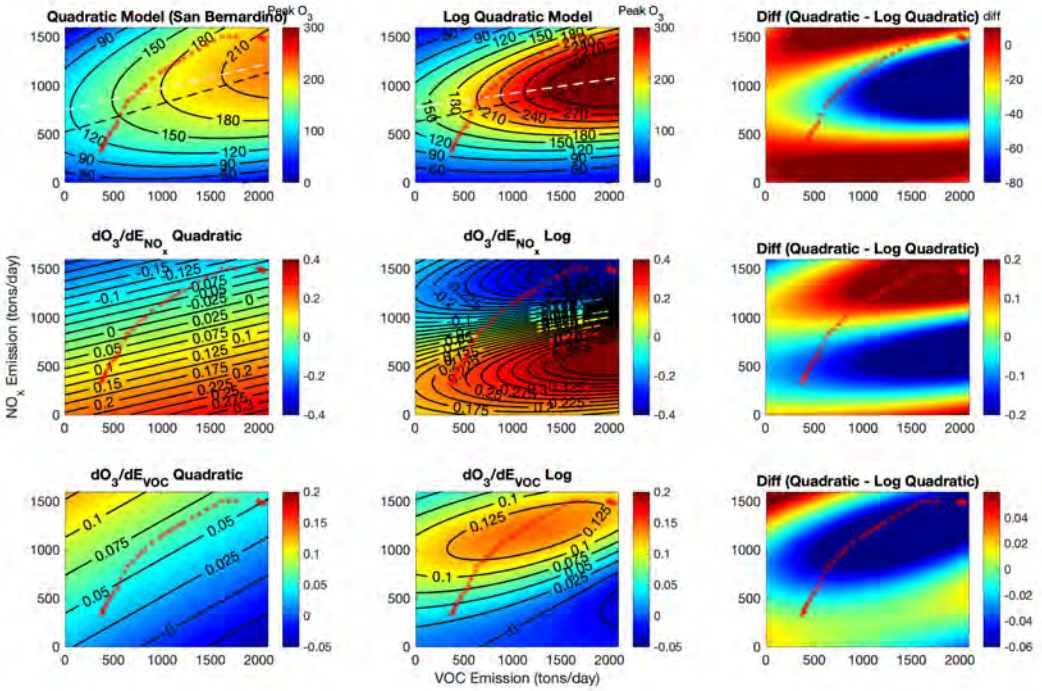

Quadratic Model (Rubidoux)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)
Quadratic Model (Lake Elsinore)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Quadratic Model (Crestline)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Quadratic Model (Upland)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Quadratic Model (Fontana)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Quadratic Model (Redlands)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Quadratic Model (San Bernardino)
Peak O3
Log Quadratic Model
Peak O3
Diff (Quadratic - Log Quadratic)
diff
dO3/dENOx Quadratic
dO3/dENOx Log
Diff (Quadratic - Log Quadratic)
dO3/dEVOC Quadratic
dO3/dEVOC Log
Diff (Quadratic - Log Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

Appendix F: Data Withholding Results Based on the CMAQ-HDDM Square-root Inverse Distance Weighted (SRIDW) Method

We evaluated the uncertainty of the developed isopleths (based on the CMAQ-HDDM square-root inverse distance weighted method) using data withholding. We used the model that was trained by all data points as the reference and evaluated the difference between the models that withheld one data point and the combined model results. The mean and standard deviation of the differences were calculated to evaluate the model's uncertainty. Here we show the isopleths of the mean and standard deviation of the differences for each individual monitoring site.

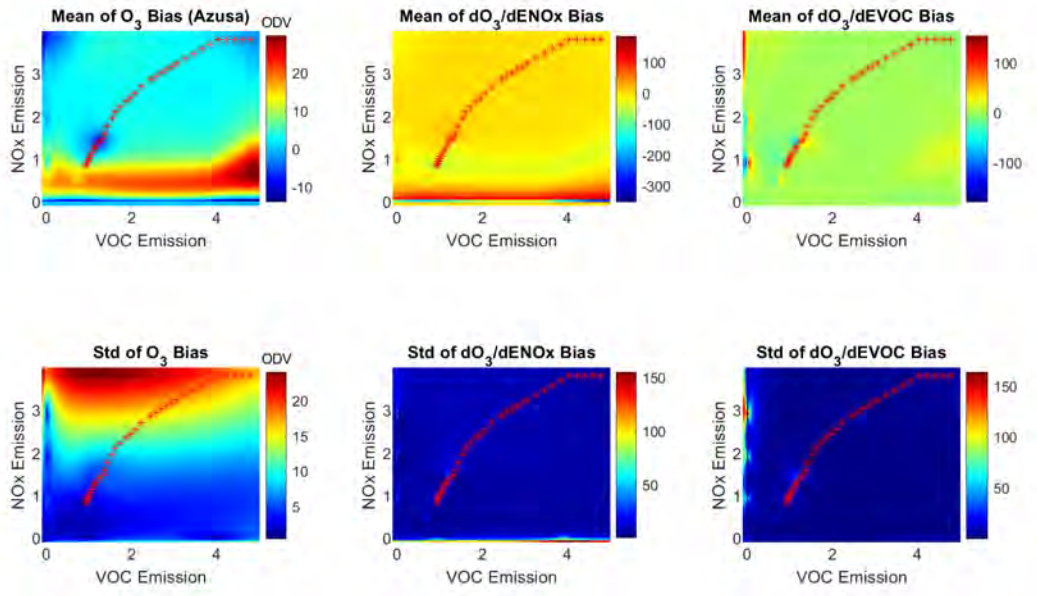
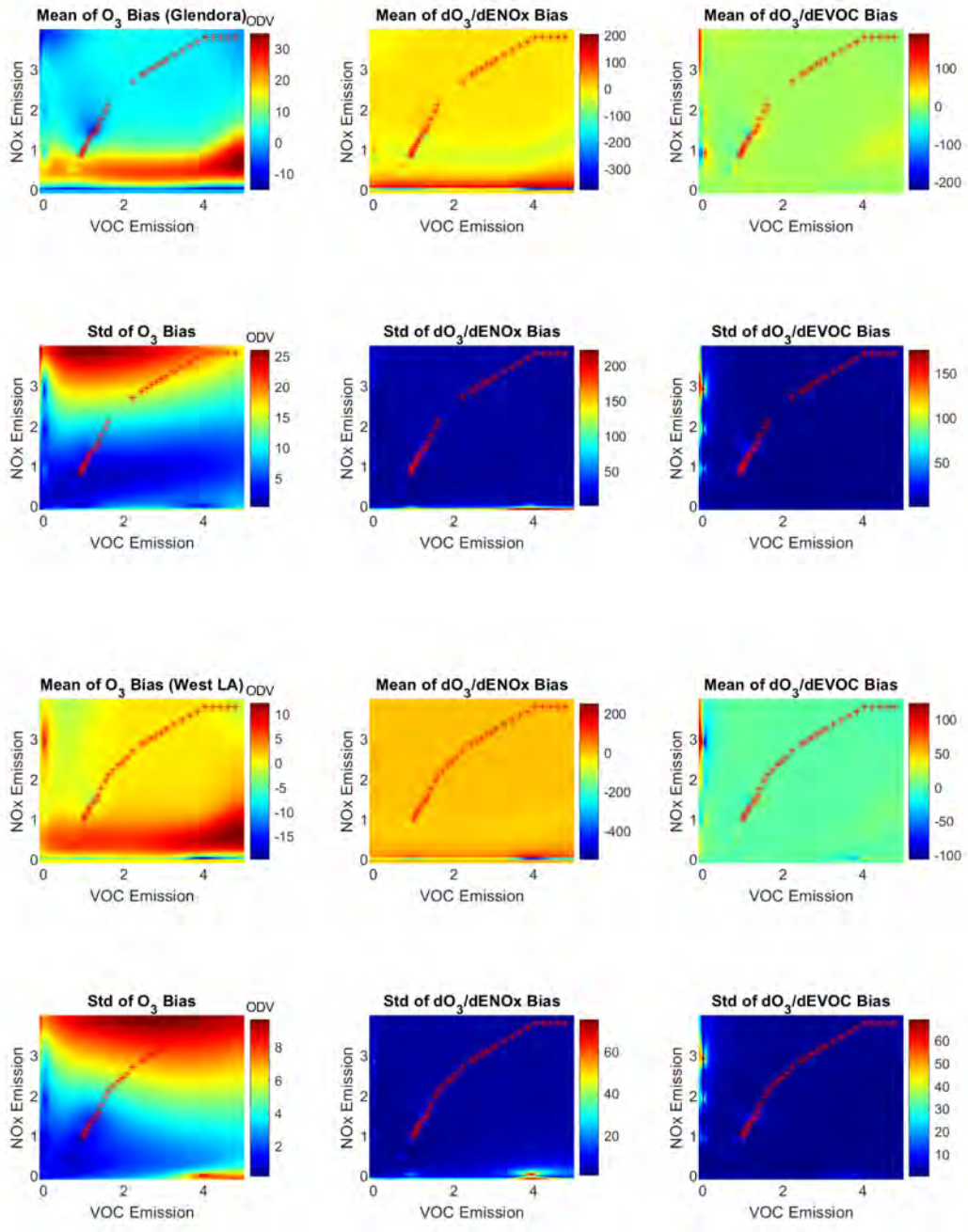
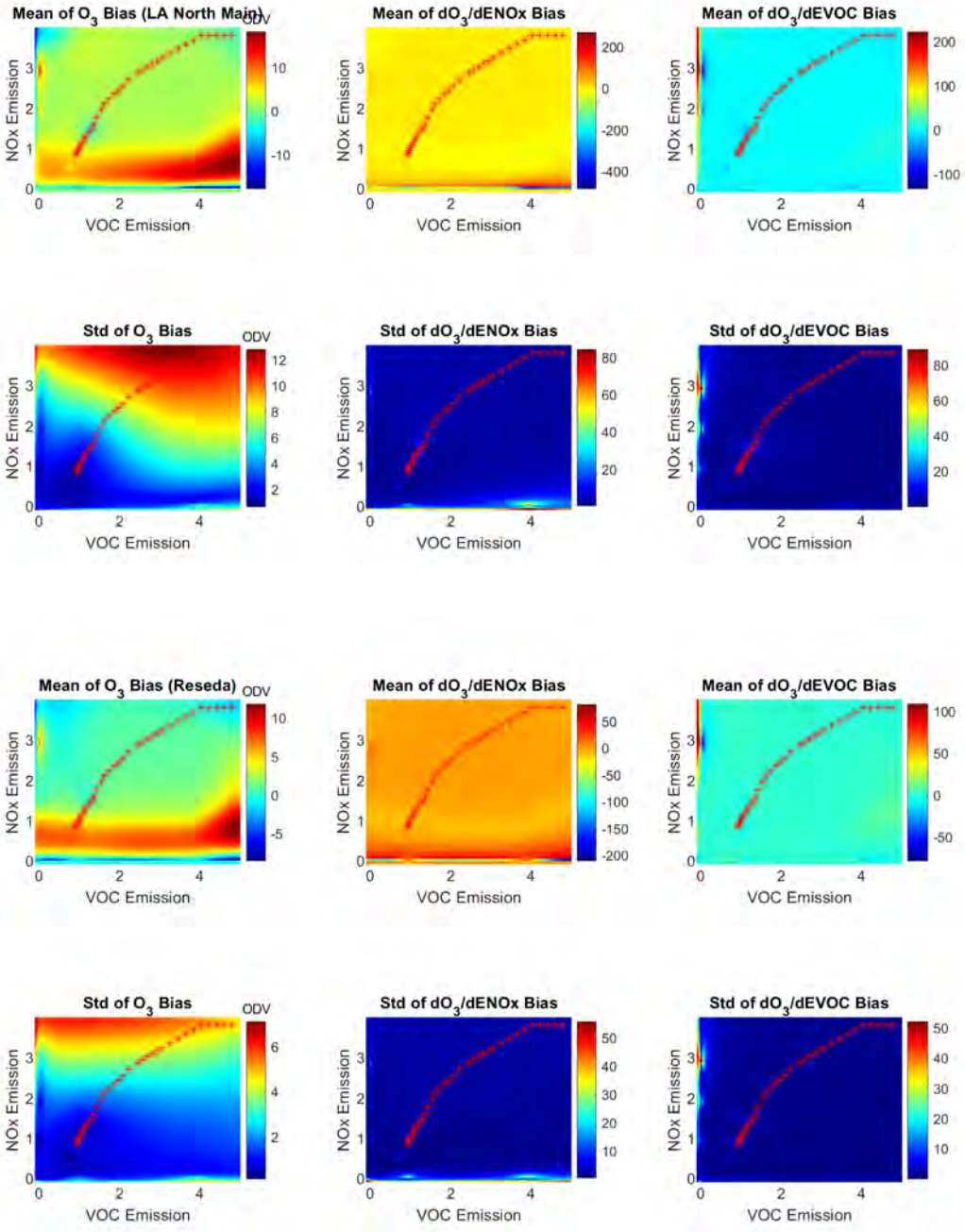
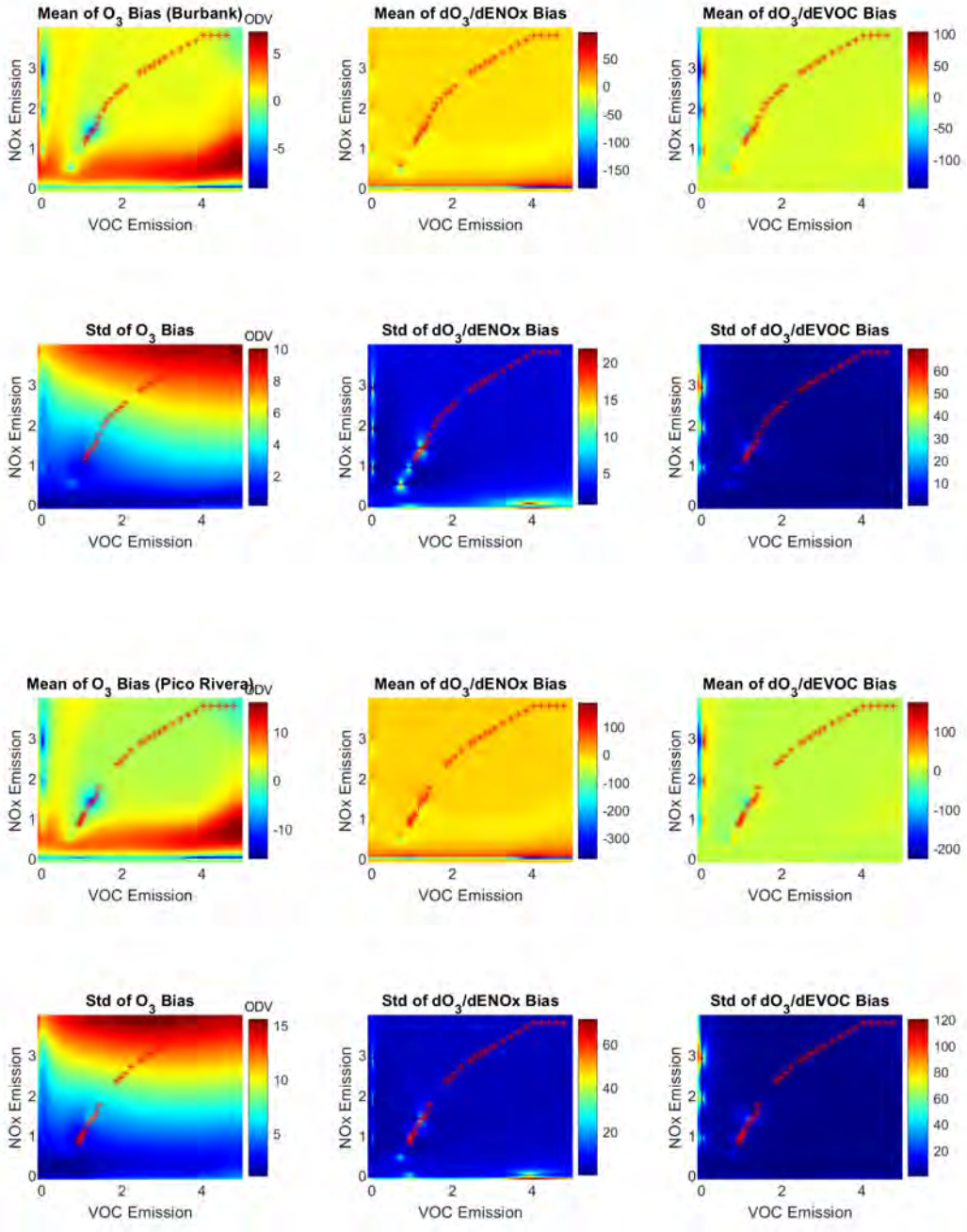
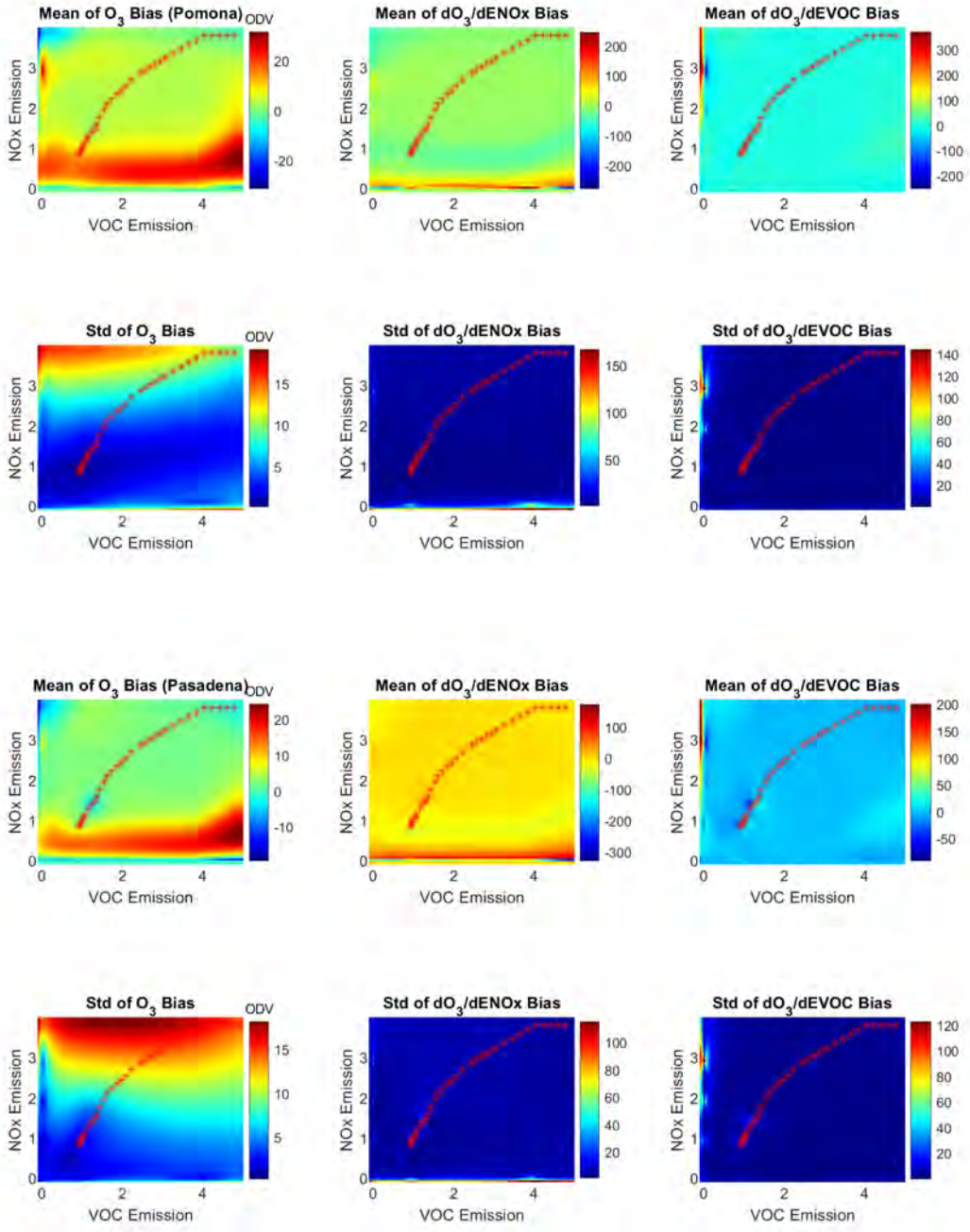


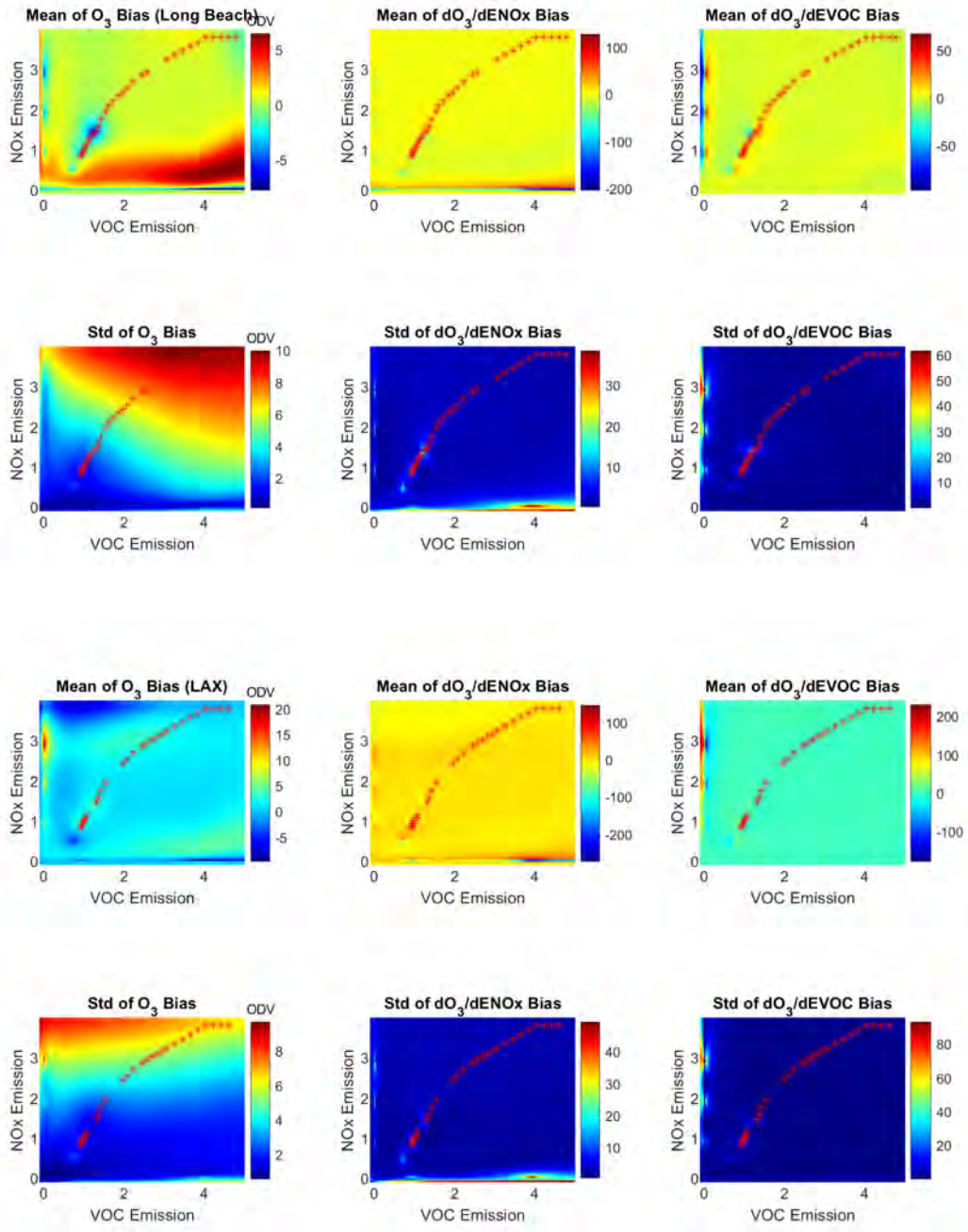
Figure F.1 Data withholding results of the CMAQ-HDDM SRIDW-based isopleth. The upper row shows isopleths of the average differences between the isopleth built by all 11 reference points and the 11 individual isopleths built by 10 reference points, with one simulation excluded. The lower row shows the standard deviation of the difference between the isopleth built by all 11 reference points and the 11 individual isopleths built by 10 reference points, with one simulation excluded. The first column shows the ozone isopleth uncertainty. The second column shows ozone-to-NOx emissions sensitivity uncertainty. The third column shows ozone-to-VOC emissions sensitivity uncertainty. The site is Azusa. Results for other sites shown below in this section follow the same layout.

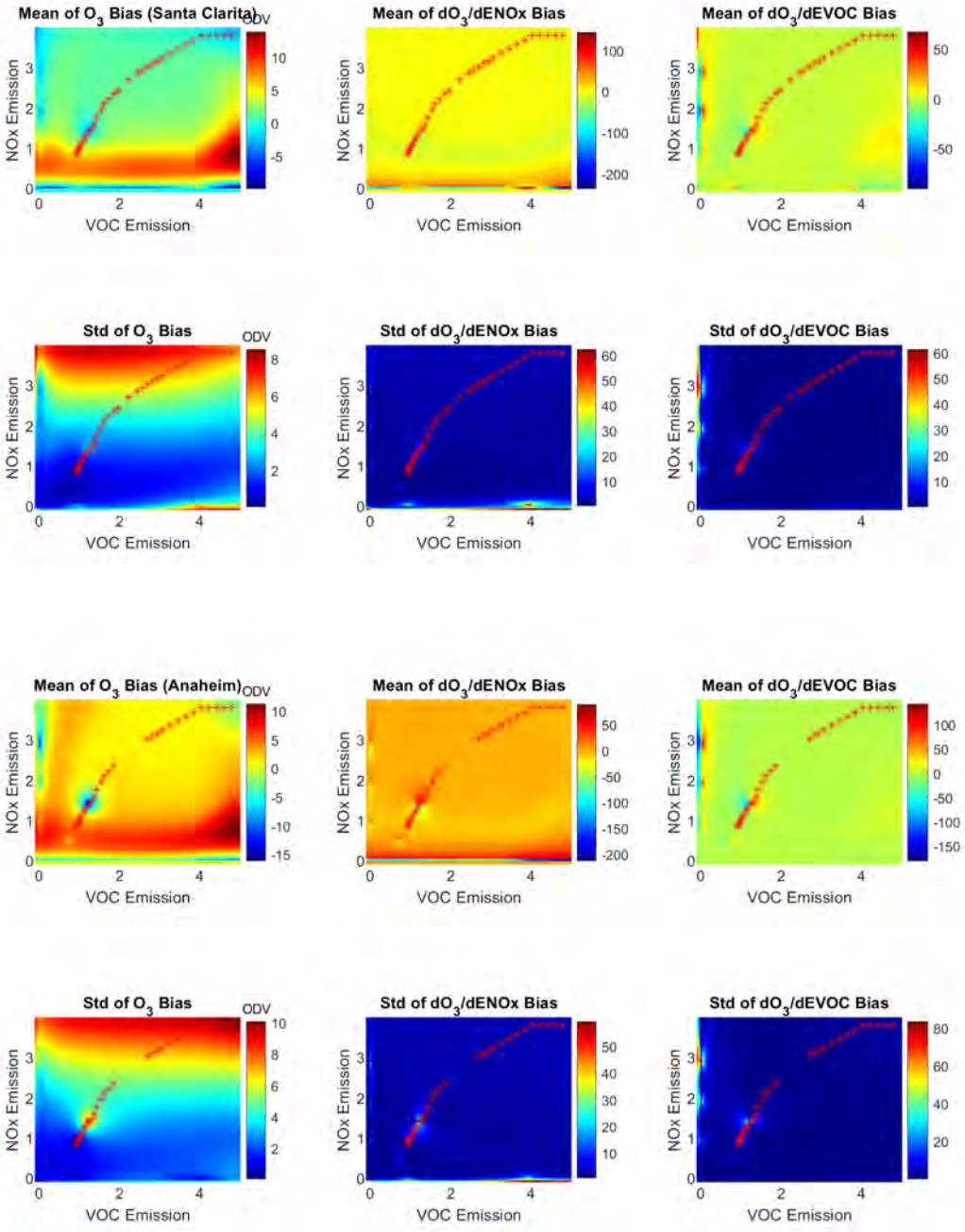

Mean of O_3 Bias (Glendora)
ODV
30
20
10
0
-10
Mean of dO_3/dENOx Bias
200
100
0
-100
-200
-300
Mean of dO_3/dEVOC Bias
100
0
-100
-200
Std of O_3 Bias
ODV
25
20
15
10
5
Std of dO_3/dENOx Bias
200
150
100
50
Std of dO_3/dEVOC Bias
150
100
50
Mean of O_3 Bias (West LA)
ODV
10
5
0
-5
-10
-15
Mean of dO_3/dENOx Bias
200
0
-200
-400
Mean of dO_3/dEVOC Bias
100
50
0
-50
-100
Std of O_3 Bias
ODV
8
6
4
2
Std of dO_3/dENOx Bias
60
40
20
Std of dO_3/dEVOC Bias
60
50
40
30
20
10
NOx Emission
VOC Emission
0
1
2
3
0
2
4

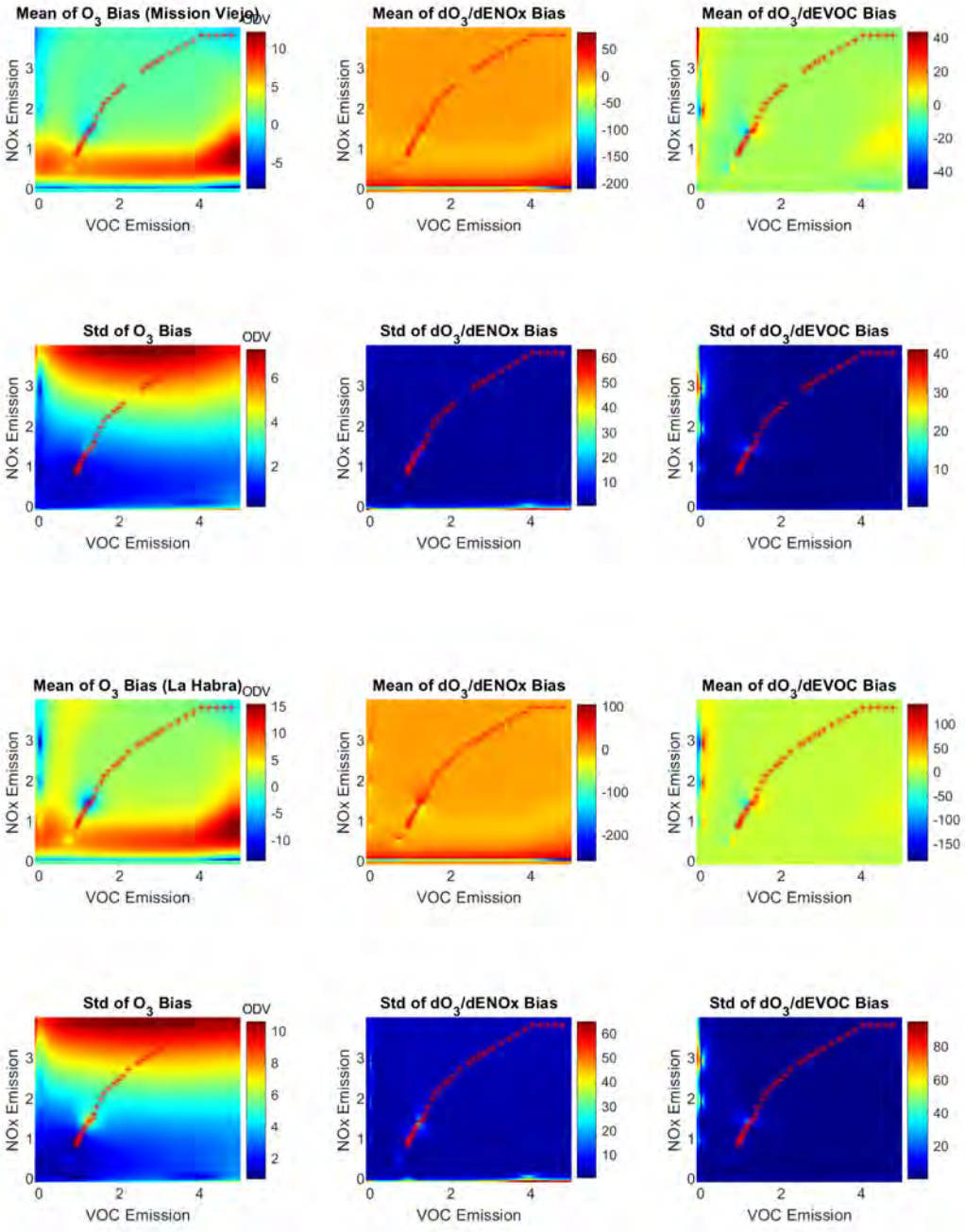

Mean of O_3 Bias (LA North Main)
ODV
10
0
-10
Mean of dO_3/dENOx Bias
200
0
-200
-400
Mean of dO_3/dEVOC Bias
200
100
0
-100
Std of O_3 Bias
ODV
12
10
8
6
4
2
Std of dO_3/dENOx Bias
80
60
40
20
Std of dO_3/dEVOC Bias
80
60
40
20
Mean of O_3 Bias (Reseda)
ODV
10
5
0
-5
Mean of dO_3/dENOx Bias
50
0
-50
-100
-150
-200
Mean of dO_3/dEVOC Bias
100
50
0
-50
Std of O_3 Bias
ODV
6
4
2
Std of dO_3/dENOx Bias
50
40
30
20
10
Std of dO_3/dEVOC Bias
50
40
30
20
10
NOx Emission
VOC Emission
0
1
2
3
4

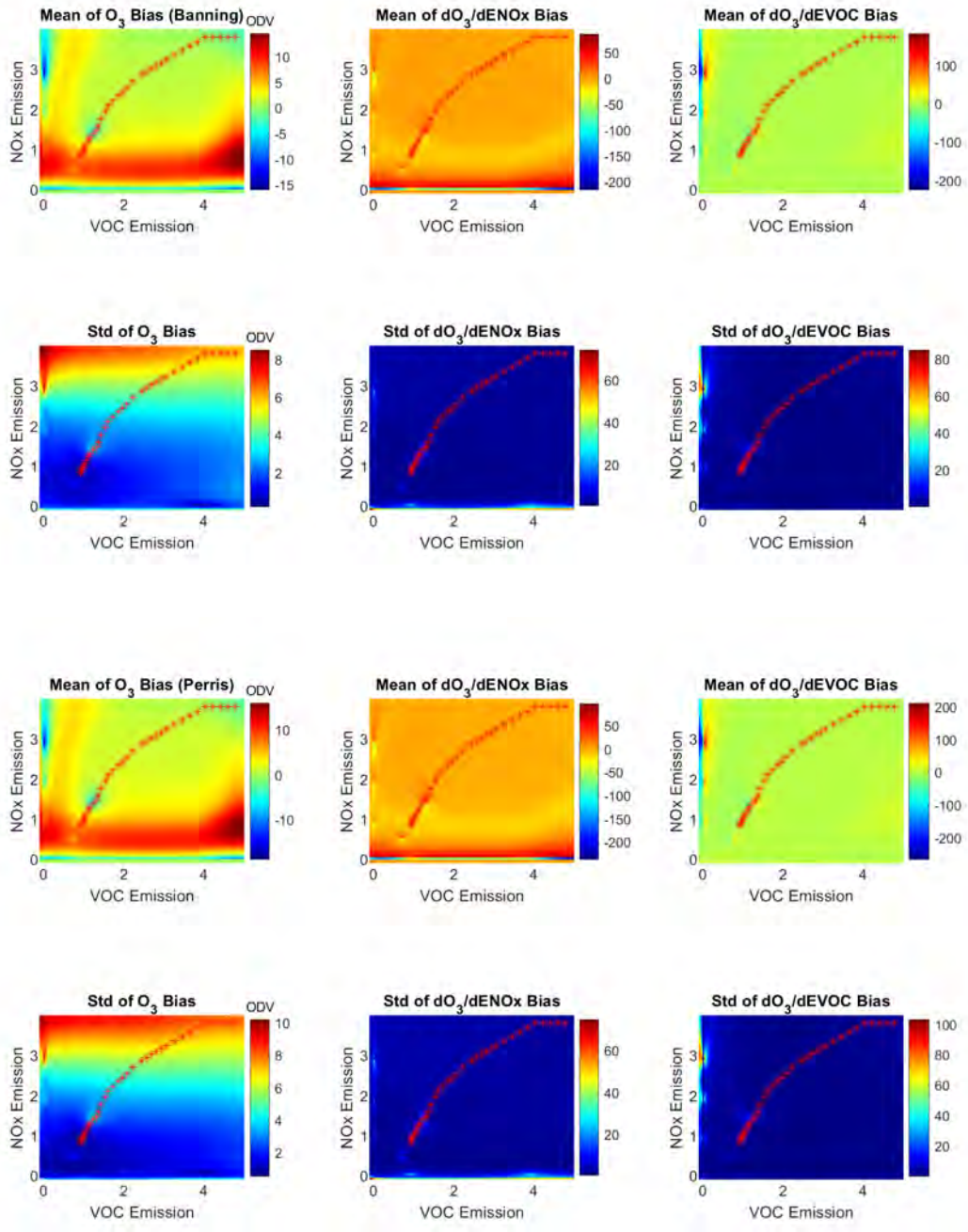

Mean of O3 Bias (Burbank)
ODV
Mean of dO3/dENOx Bias
Mean of dO3/dEVOC Bias
Std of O3 Bias
Std of dO3/dENOx Bias
Std of dO3/dEVOC Bias
Mean of O3 Bias (Pico Rivera)
Mean of dO3/dENOx Bias
Mean of dO3/dEVOC Bias
Std of O3 Bias
Std of dO3/dENOx Bias
Std of dO3/dEVOC Bias
NOx Emission
VOC Emission

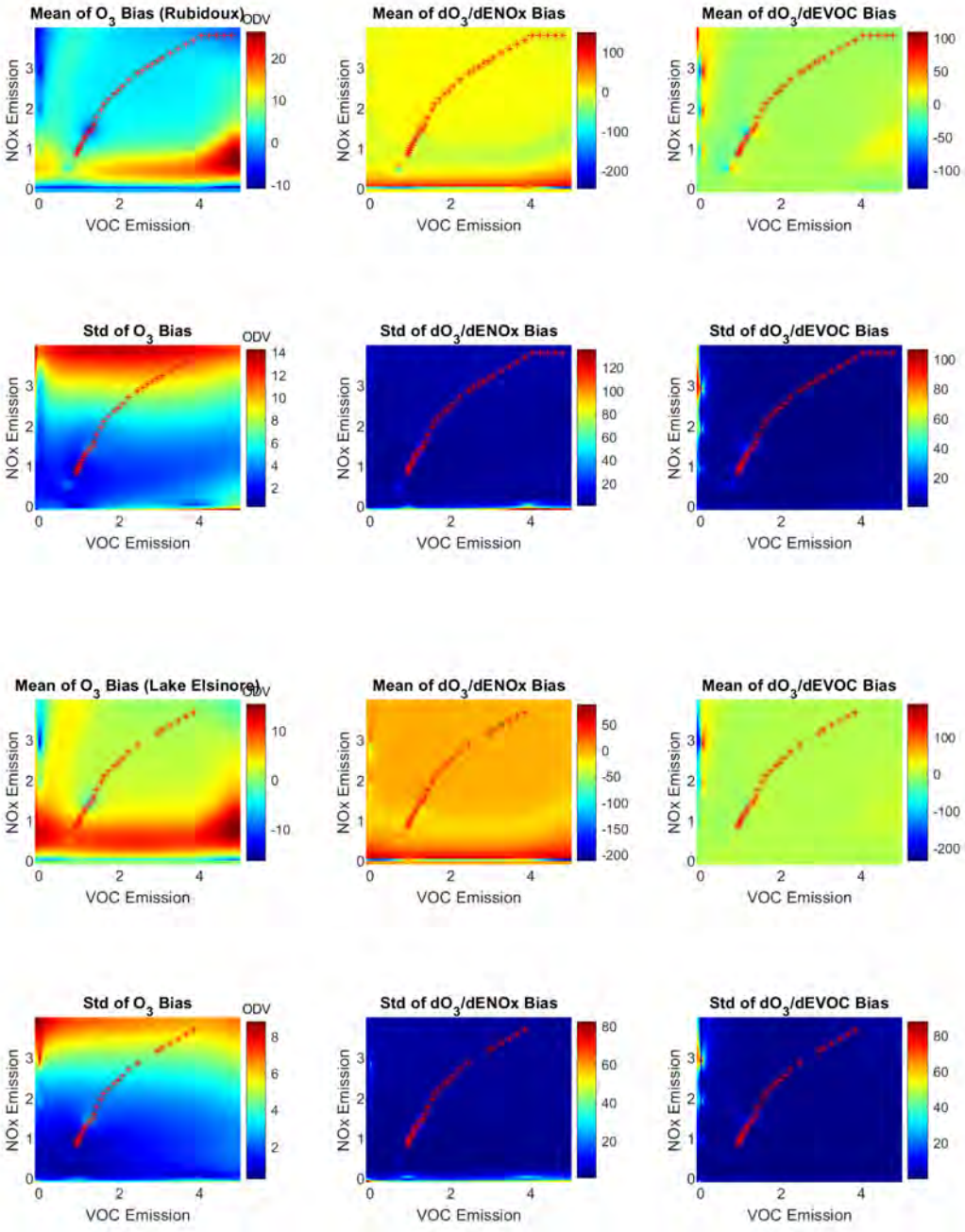

Mean of O_3 Bias (Pomona)
ODV
20
0
-20
Mean of dO_3/dENOx Bias
200
100
0
-100
-200
Mean of dO_3/dEVOC Bias
300
200
100
0
-100
-200
Std of O_3 Bias
ODV
15
10
5
Std of dO_3/dENOx Bias
150
100
50
Std of dO_3/dEVOC Bias
140
120
100
80
60
40
20
Mean of O_3 Bias (Pasadena)
ODV
20
10
0
-10
Mean of dO_3/dENOx Bias
100
0
-100
-200
-300
Mean of dO_3/dEVOC Bias
200
150
100
50
0
-50
Std of O_3 Bias
ODV
15
10
5
Std of dO_3/dENOx Bias
100
80
60
40
20
Std of dO_3/dEVOC Bias
120
100
80
60
40
20
NOx Emission
VOC Emission
0
1
2
3
0
2
4

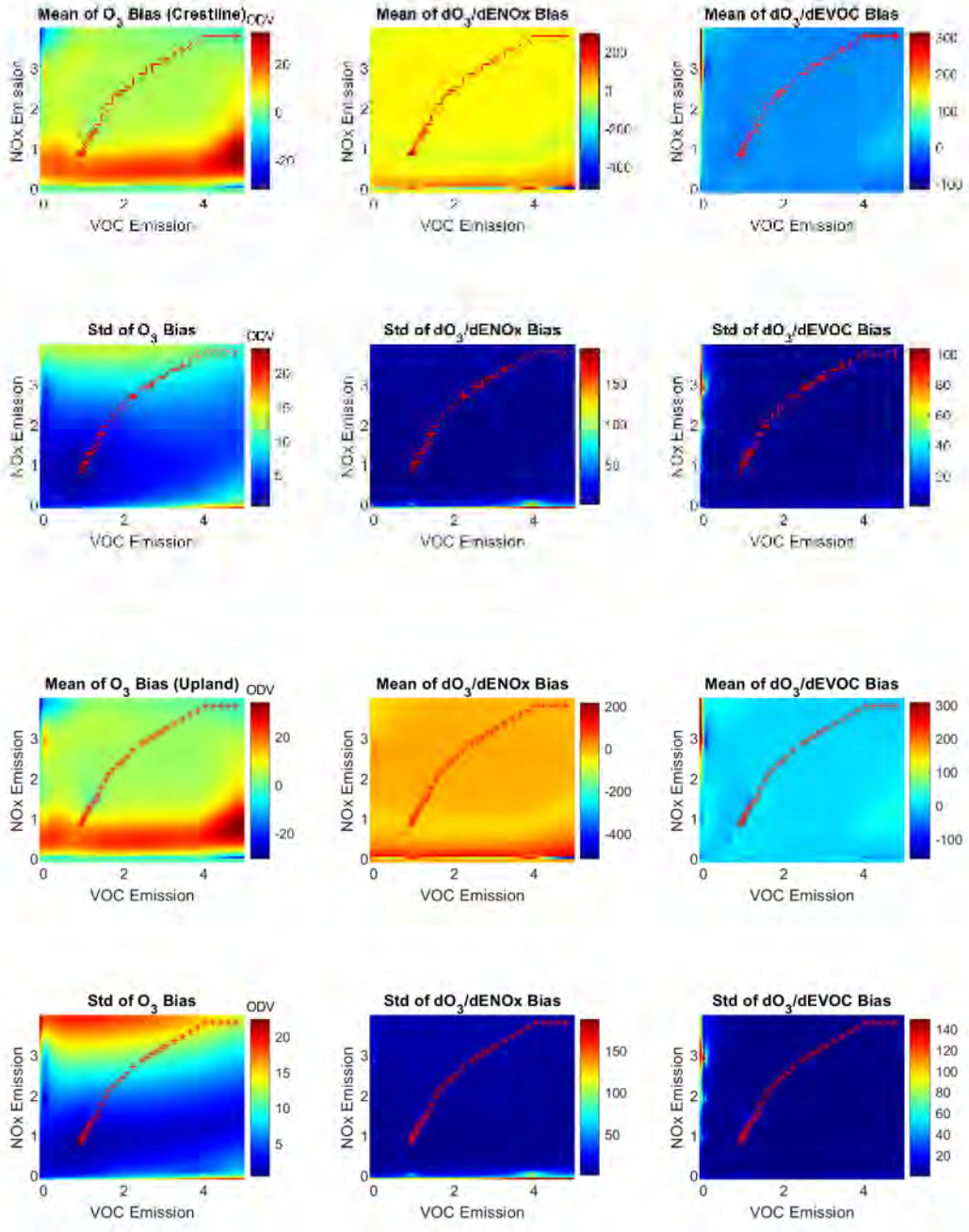

Mean of O_3 Bias (Long Beach)
ODV
5
0
-5
NOx Emission
VOC Emission
Mean of dO_3/dENOx Bias
100
0
-100
-200
Mean of dO_3/dEVOC Bias
50
0
-50
Std of O_3 Bias
10
8
6
4
2
Std of dO_3/dENOx Bias
30
20
10
Std of dO_3/dEVOC Bias
60
50
40
30
20
10
Mean of O_3 Bias (LAX)
20
15
10
5
0
-5
Mean of dO_3/dENOx Bias
100
0
-100
-200
Mean of dO_3/dEVOC Bias
200
100
0
-100
Std of O_3 Bias
8
6
4
2
Std of dO_3/dENOx Bias
40
30
20
10
Std of dO_3/dEVOC Bias
80
60
40
20

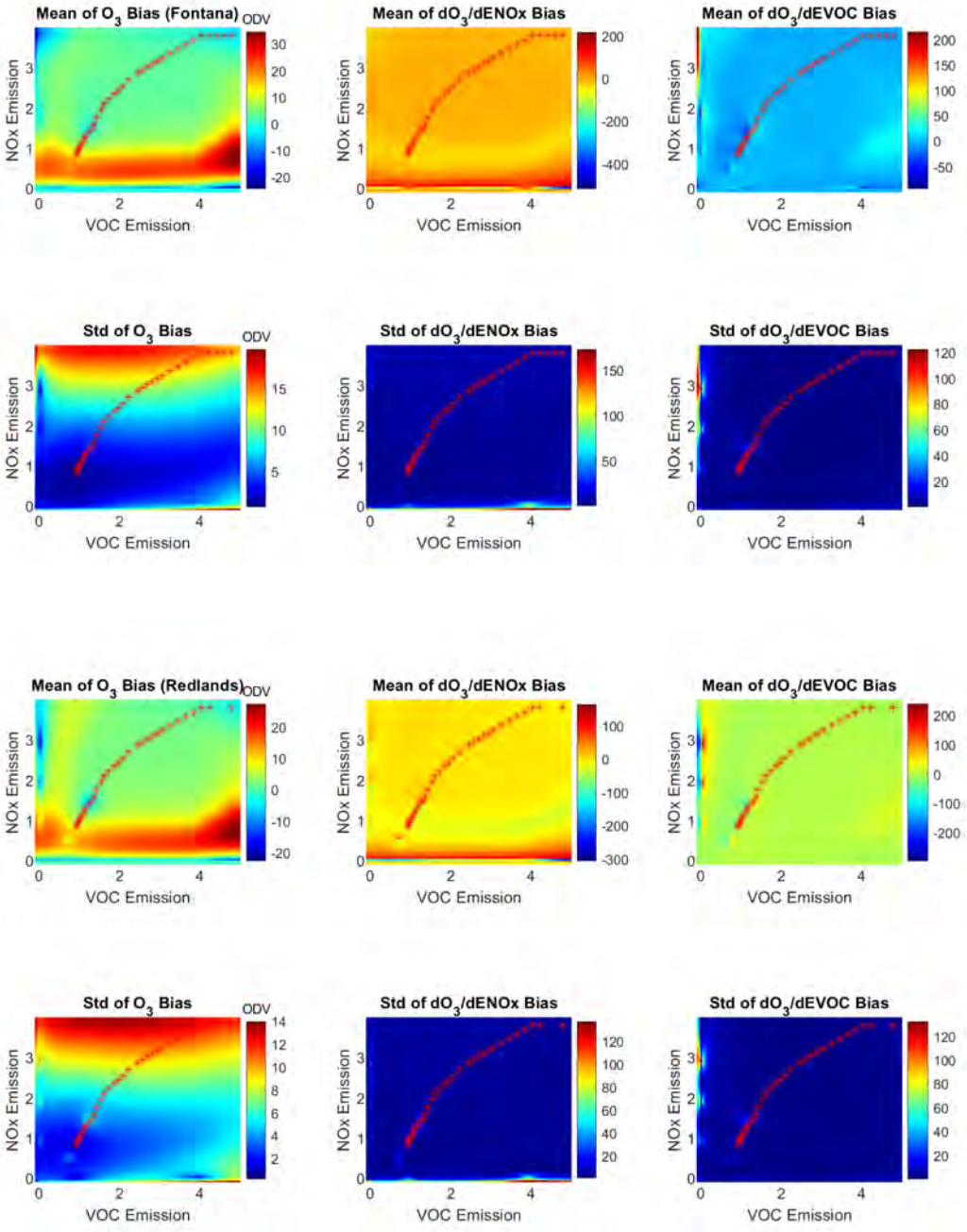

Mean of O_3 Bias (Santa Clarita)
ODV
10
5
0
-5
Mean of dO_3/dENOx Bias
100
0
-100
-200
Mean of dO_3/dEVOC Bias
50
0
-50
Std of O_3 Bias
ODV
8
6
4
2
Std of dO_3/dENOx Bias
60
50
40
30
20
10
Std of dO_3/dEVOC Bias
60
50
40
30
20
10
Mean of O_3 Bias (Anaheim)
ODV
10
5
0
-5
-10
-15
Mean of dO_3/dENOx Bias
50
0
-50
-100
-150
-200
Mean of dO_3/dEVOC Bias
100
50
0
-50
-100
-150
Std of O_3 Bias
ODV
10
8
6
4
2
Std of dO_3/dENOx Bias
50
40
30
20
10
Std of dO_3/dEVOC Bias
80
60
40
20
NOx Emission
VOC Emission
0
1
2
3
4

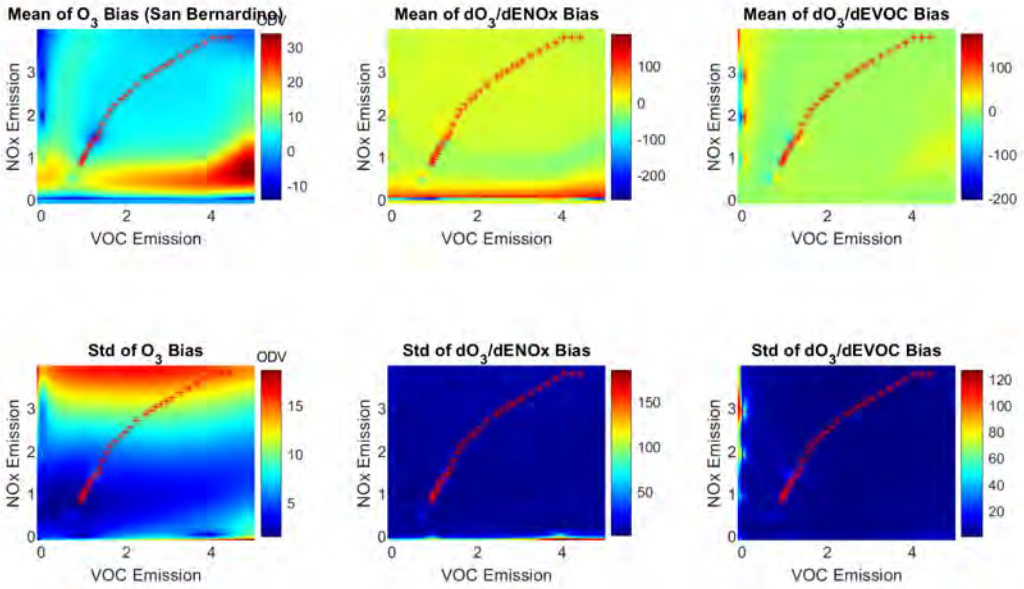

Mean of O_3 Bias (Mission Viejo)
ODV
10
5
0
-5
Mean of dO_3/dENOx Bias
50
0
-50
-100
-150
-200
Mean of dO_3/dEVOC Bias
40
20
0
-20
-40
Std of O_3 Bias
ODV
6
4
2
Std of dO_3/dENOx Bias
60
50
40
30
20
10
Std of dO_3/dEVOC Bias
40
30
20
10
Mean of O_3 Bias (La Habra)
ODV
15
10
5
0
-5
-10
Mean of dO_3/dENOx Bias
100
0
-100
-200
Mean of dO_3/dEVOC Bias
100
50
0
-50
-100
-150
Std of O_3 Bias
ODV
10
8
6
4
2
Std of dO_3/dENOx Bias
60
50
40
30
20
10
Std of dO_3/dEVOC Bias
80
60
40
20
NOx Emission
VOC Emission
0
1
2
3
0
2
4


Mean of O_3 Bias (Banning)
ODV
Mean of dO_3/dENOx Bias
Mean of dO_3/dEVOC Bias
Std of O_3 Bias
Std of dO_3/dENOx Bias
Std of dO_3/dEVOC Bias
Mean of O_3 Bias (Perris)
Std of O_3 Bias
NOx Emission
VOC Emission


Mean of O_3 Bias (Rubidoux)
ODV
20
10
0
-10
Mean of dO_3/dENOx Bias
100
0
-100
-200
Mean of dO_3/dEVOC Bias
100
50
0
-50
-100
Std of O_3 Bias
ODV
14
12
10
8
6
4
2
Std of dO_3/dENOx Bias
120
100
80
60
40
20
Std of dO_3/dEVOC Bias
100
80
60
40
20
Mean of O_3 Bias (Lake Elsinore)
ODV
10
0
-10
Mean of dO_3/dENOx Bias
50
0
-50
-100
-150
-200
Mean of dO_3/dEVOC Bias
100
0
-100
-200
Std of O_3 Bias
ODV
8
6
4
2
Std of dO_3/dENOx Bias
80
60
40
20
Std of dO_3/dEVOC Bias
80
60
40
20
NOx Emission
VOC Emission
0
1
2
3
0
2
4


Mean of O_3 Bias (Crestline)
ODV
Mean of dO_3/dENOx Bias
Mean of dO_3/dEVOC Bias
Std of O_3 Bias
Std of dO_3/dENOx Bias
Std of dO_3/dEVOC Bias
Mean of O_3 Bias (Upland)
NOx Emission
VOC Emission


Mean of O_3 Bias (Fontana)
ODV
30
20
10
0
-10
-20
Mean of dO_3/dENOx Bias
200
0
-200
-400
Mean of dO_3/dEVOC Bias
200
150
100
50
0
-50
Std of O_3 Bias
ODV
15
10
5
Std of dO_3/dENOx Bias
150
100
50
Std of dO_3/dEVOC Bias
120
100
80
60
40
20
Mean of O_3 Bias (Redlands)
ODV
20
10
0
-10
-20
Mean of dO_3/dENOx Bias
100
0
-100
-200
-300
Mean of dO_3/dEVOC Bias
200
100
0
-100
-200
Std of O_3 Bias
ODV
14
12
10
8
6
4
2
Std of dO_3/dENOx Bias
120
100
80
60
40
20
Std of dO_3/dEVOC Bias
120
100
80
60
40
20
NOx Emission
VOC Emission
0
1
2
3
0
2
4


Mean of O_3 Bias (San Bernardino)
ODV
30
20
10
0
-10
NOx Emission
VOC Emission
Mean of dO_3/dENOx Bias
100
0
-100
-200
Mean of dO_3/dEVOC Bias
Std of O_3 Bias
15
10
5
Std of dO_3/dENOx Bias
150
100
50
Std of dO_3/dEVOC Bias
120
100
80
60
40
20

Appendix G: Data Withholding Results Based on the CMAQ-HDDM Quadratic Fitting Method

We evaluated the uncertainty of the developed isopleths (based on CMAQ-HDDM quadratic fitting method) using data withholding. We used the model that was trained by all data points as the reference and evaluated the difference between the models that withheld one data point and the combined model results. The mean and standard deviation of the differences were calculated to evaluate the model's uncertainty. Here we show the isopleths of the mean and standard deviation of the differences for each individual monitoring site.

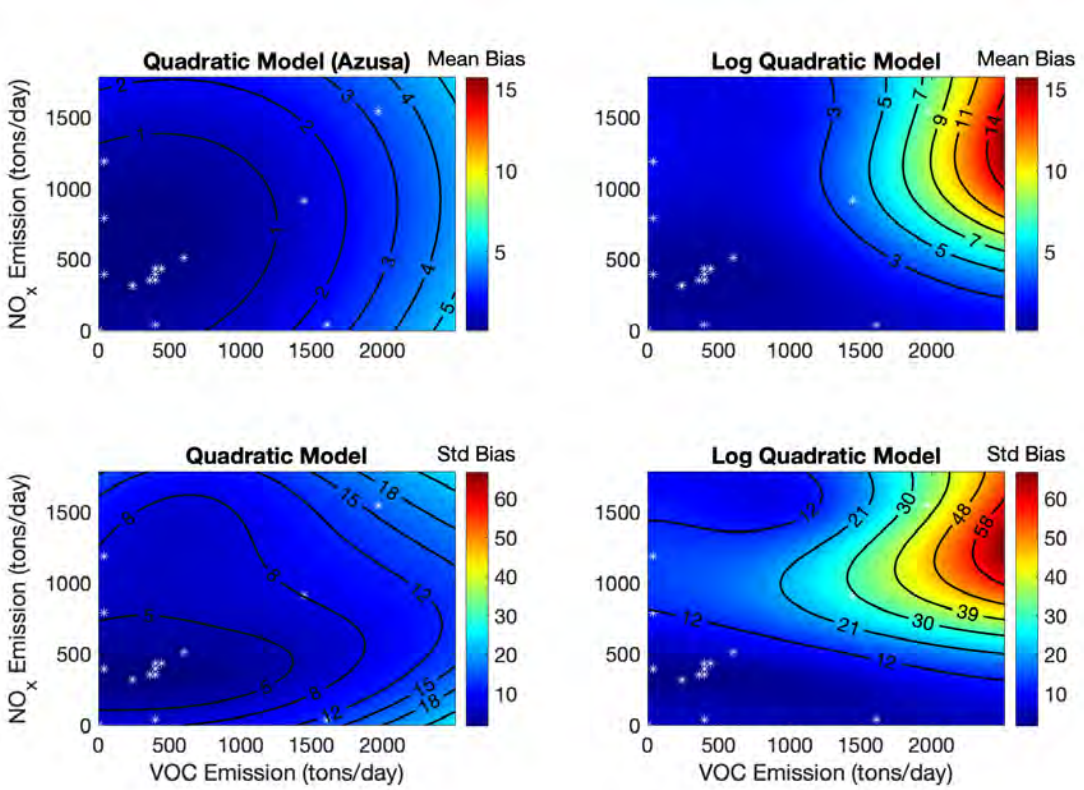
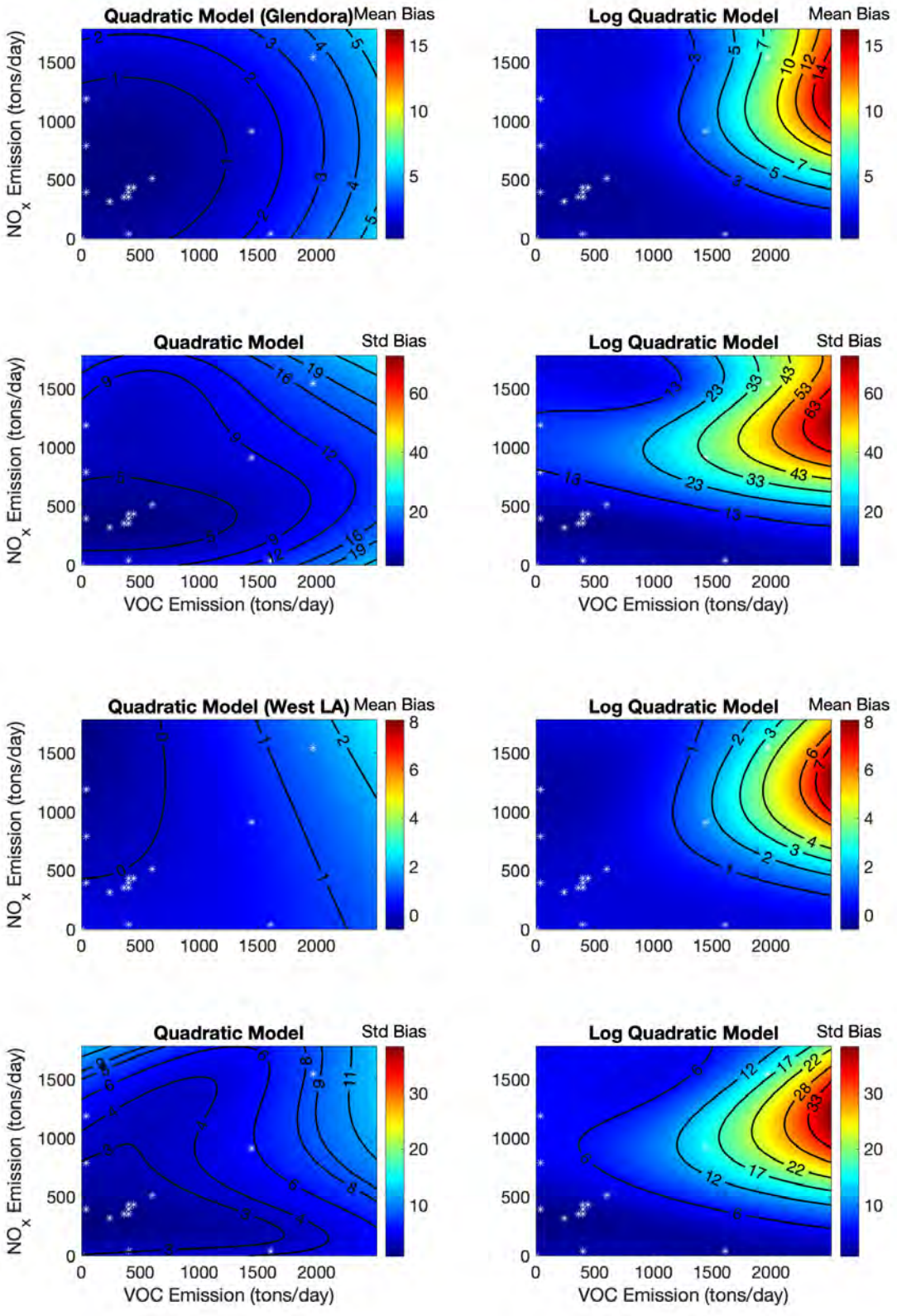
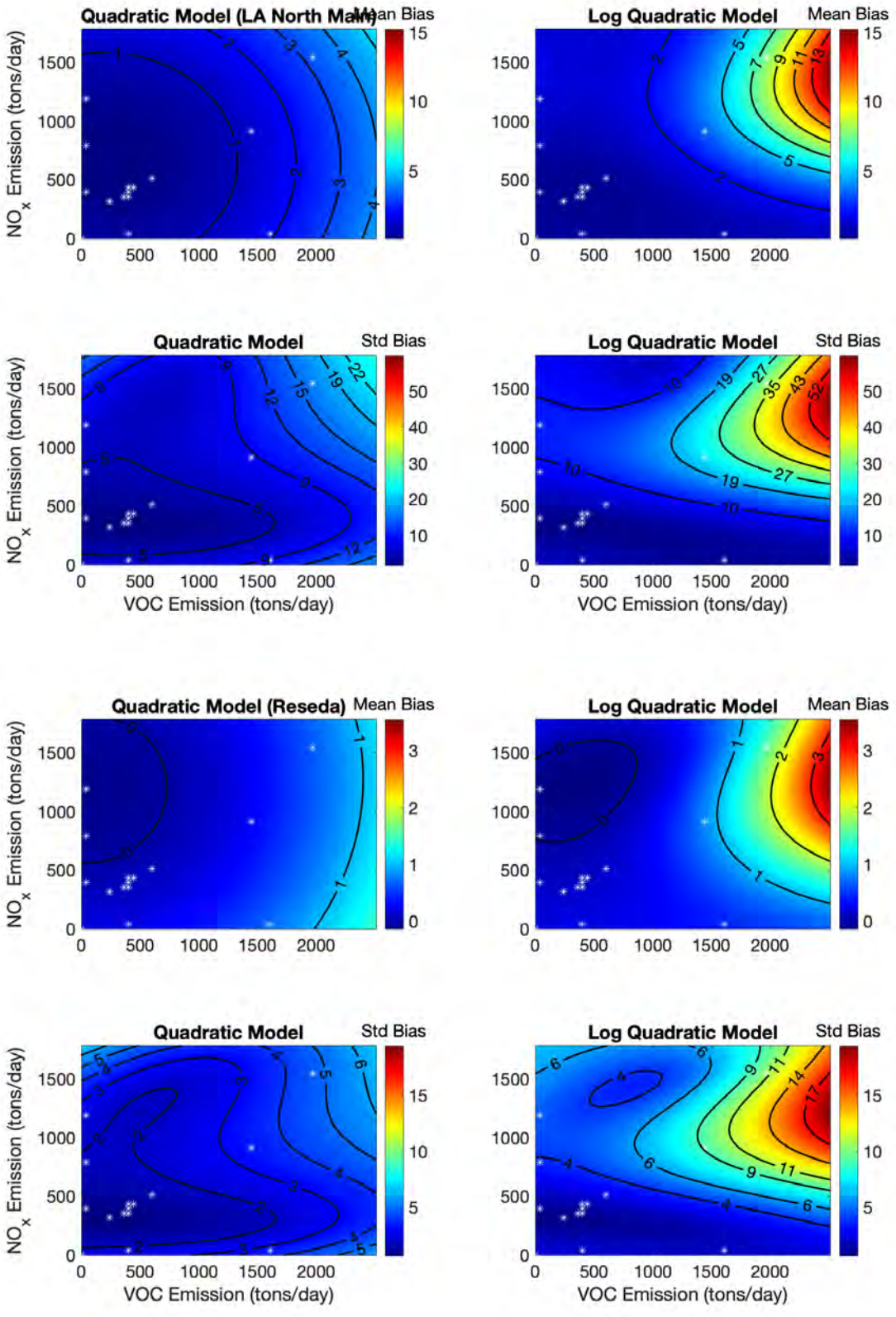
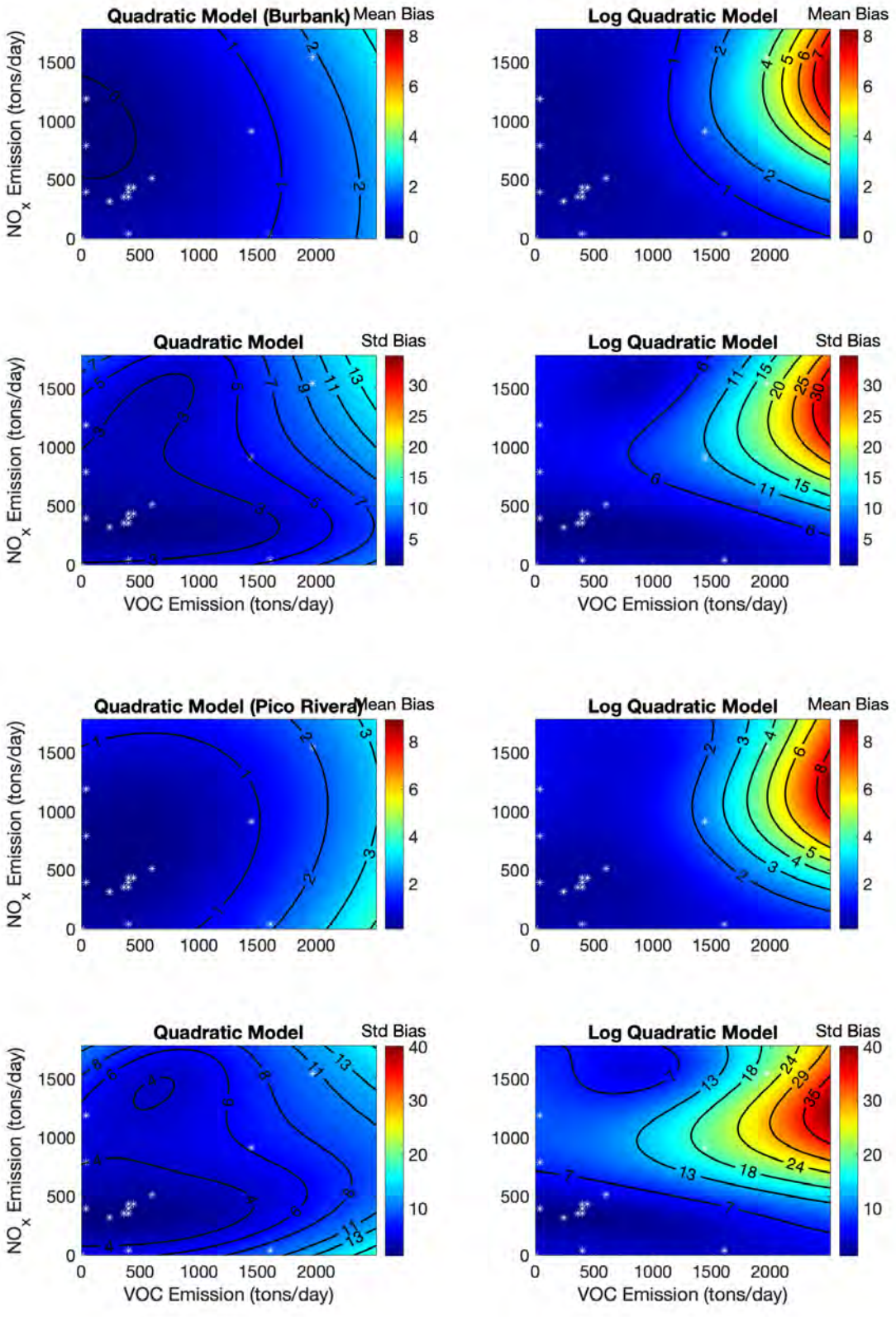
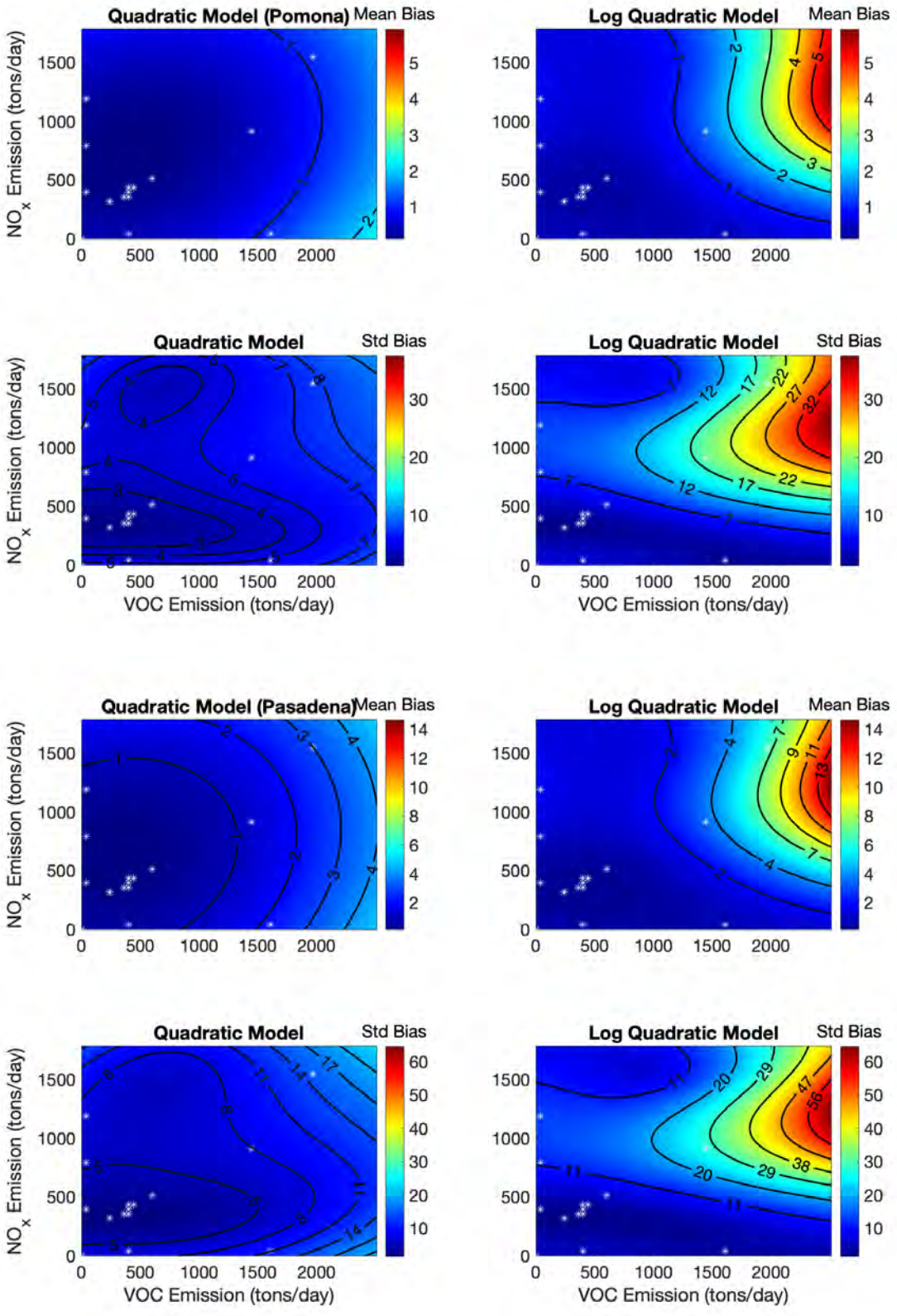


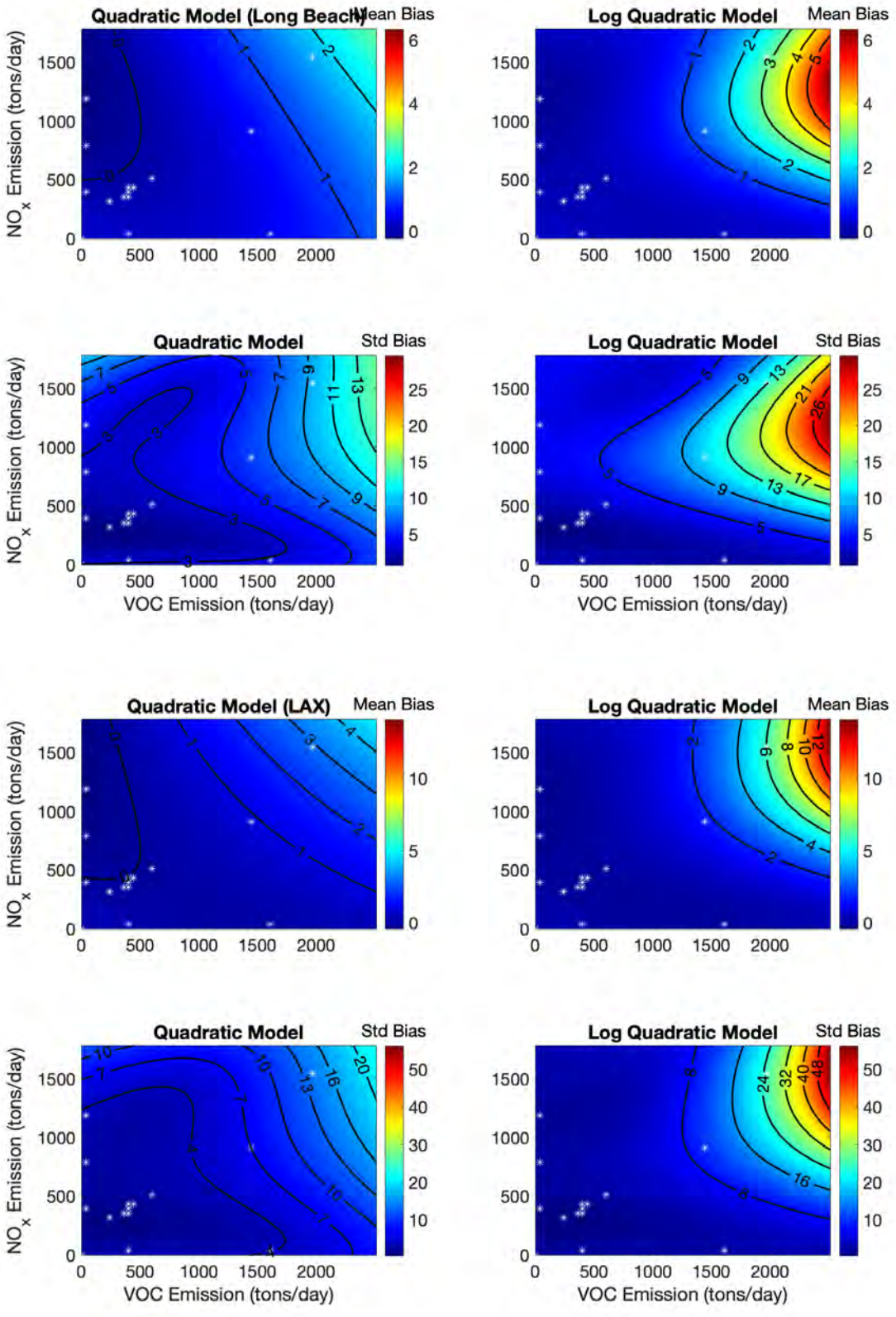
Figure G.1 Data withholding results of the CMAQ-HDDM quadratic fitting-based isopleth. The upper row shows isopleths of the average differences between the isopleth built by all 11 reference points and the 11 individual isopleths built by 10 reference points, with one simulation excluded. The lower row shows the standard deviation of the difference between the isopleth built by all 11 reference points and the 11 individual isopleths built by 10 reference points, with one simulation excluded. The first column shows the base model results. The second column shows the log model results. The site is Azusa. Results for other sites shown below in this section follow the same layout.

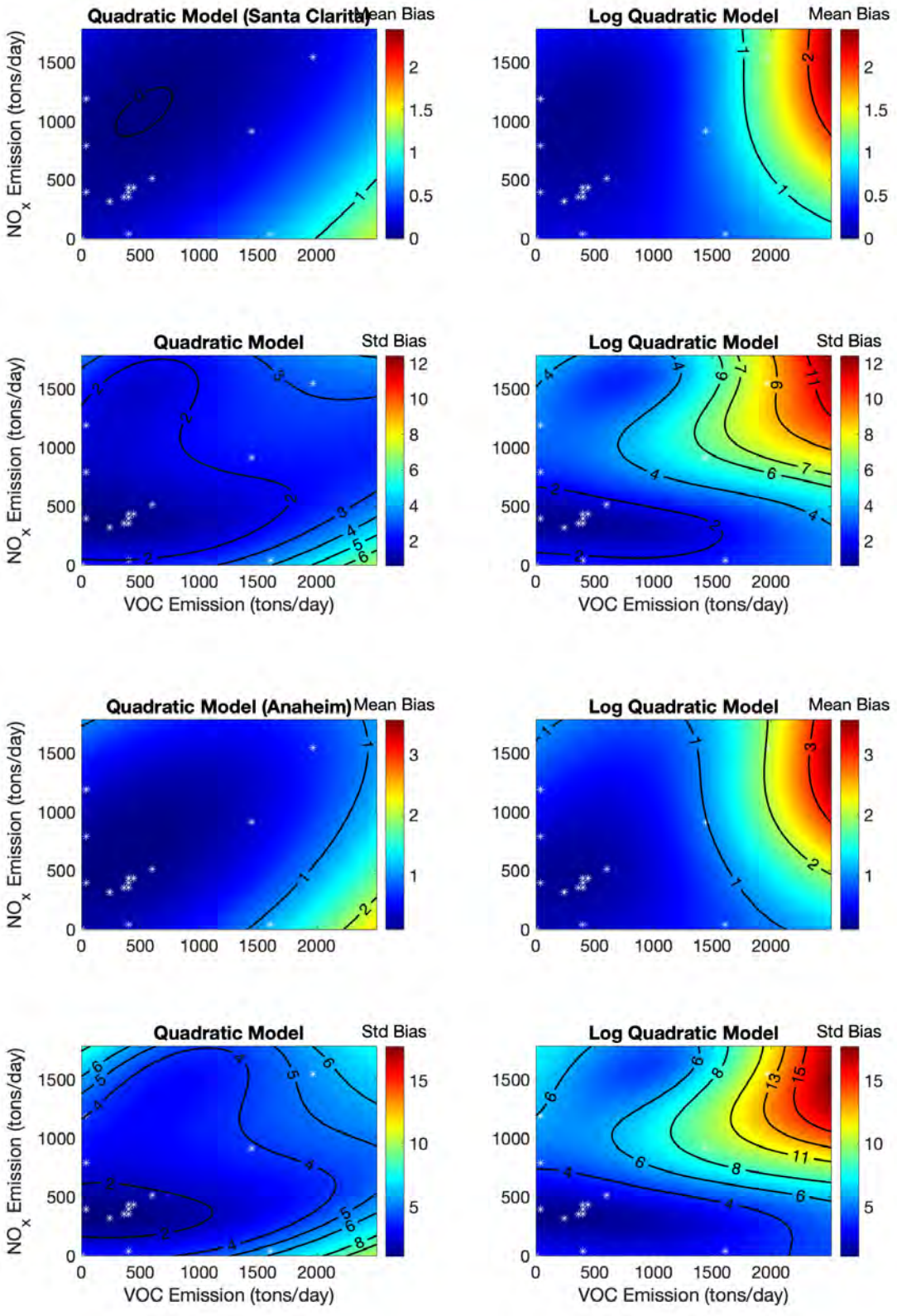

Quadratic Model (Glendora)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (West LA)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000
5
10
15
20
40
60
2
4
6
8
10
30

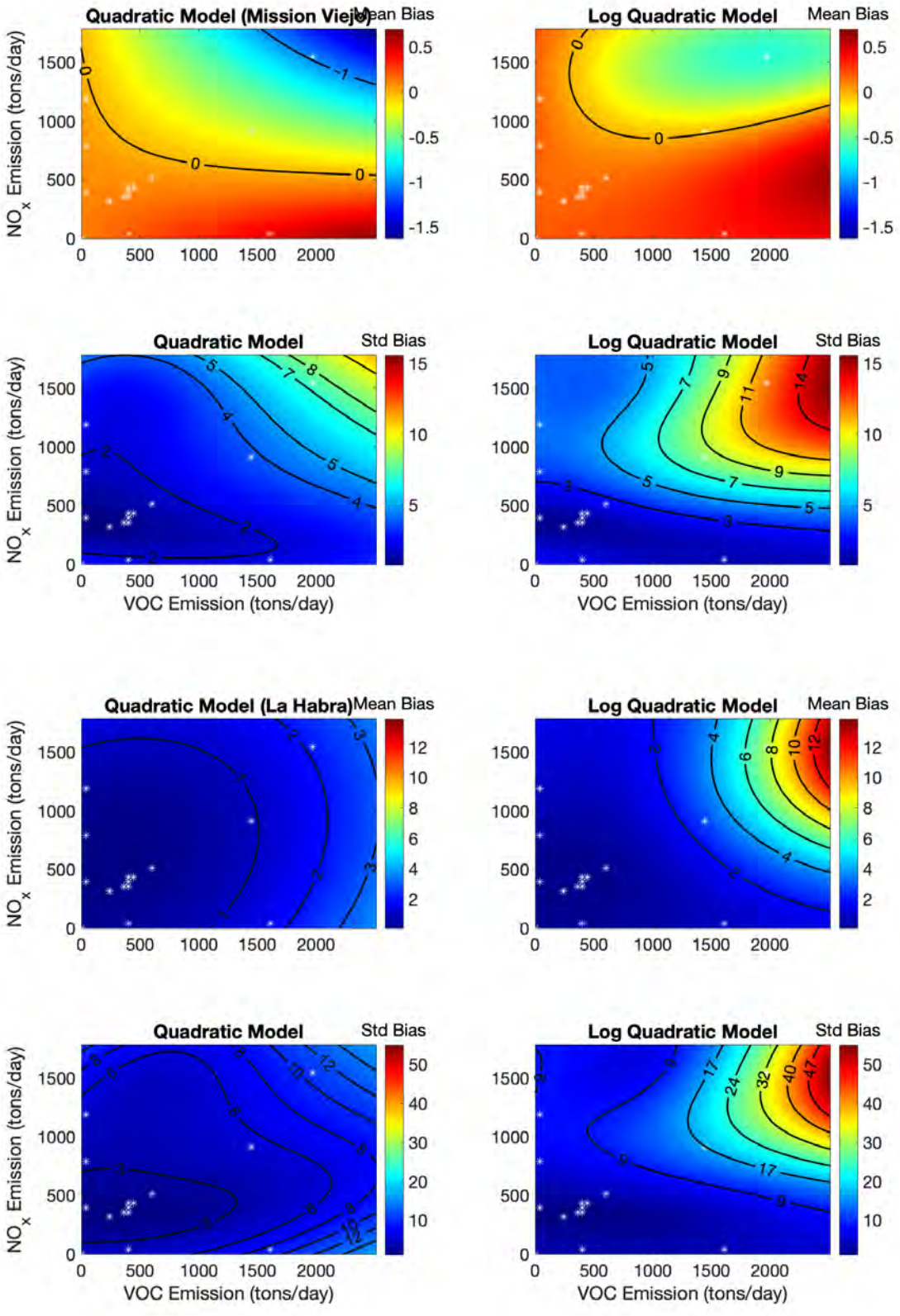

Quadratic Model (LA North Main) Mean Bias
Log Quadratic Model Mean Bias
Quadratic Model Std Bias
Log Quadratic Model Std Bias
Quadratic Model (Reseda) Mean Bias
Log Quadratic Model Mean Bias
Quadratic Model Std Bias
Log Quadratic Model Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000

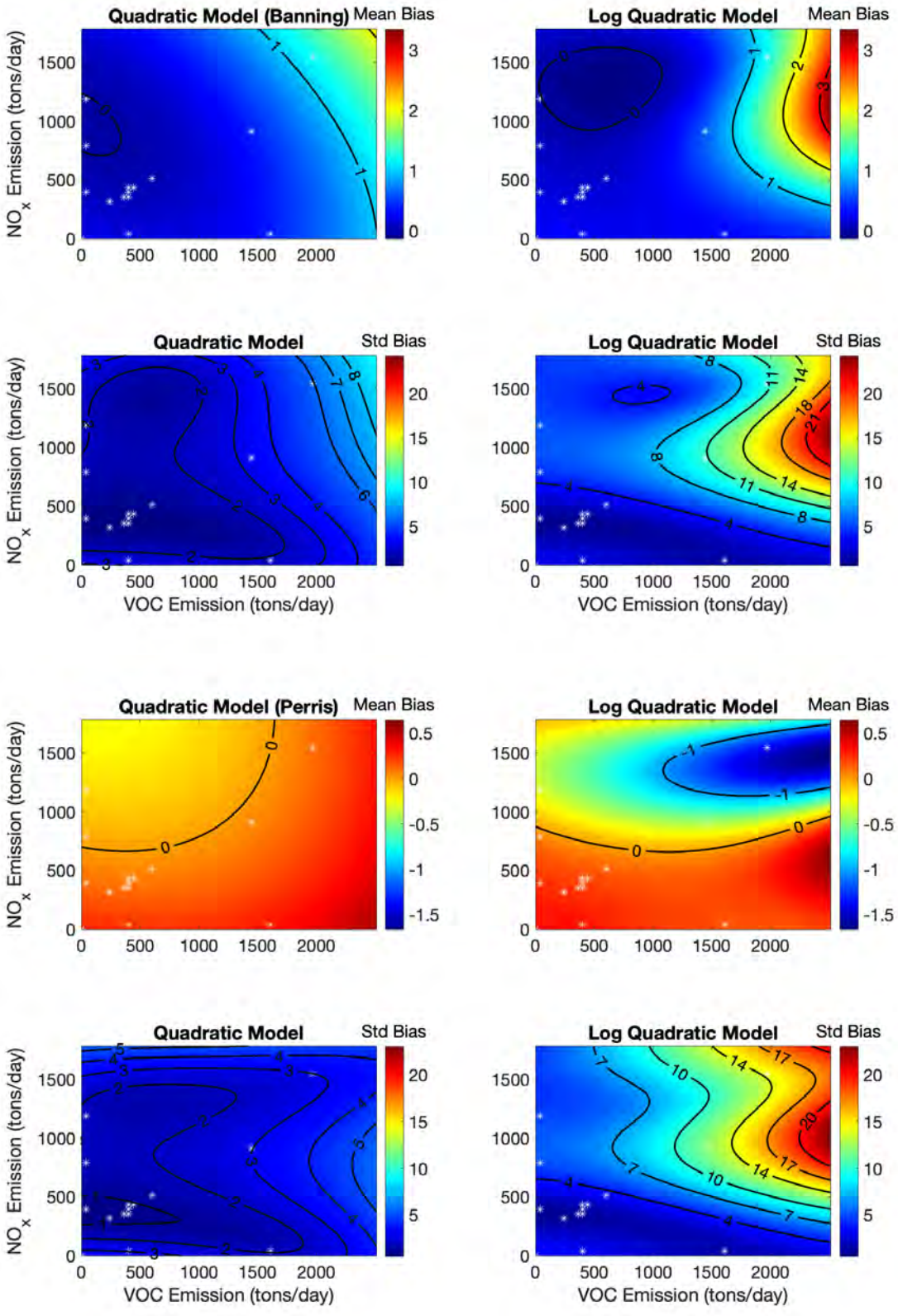

Quadratic Model (Burbank)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (Pico Rivera)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000

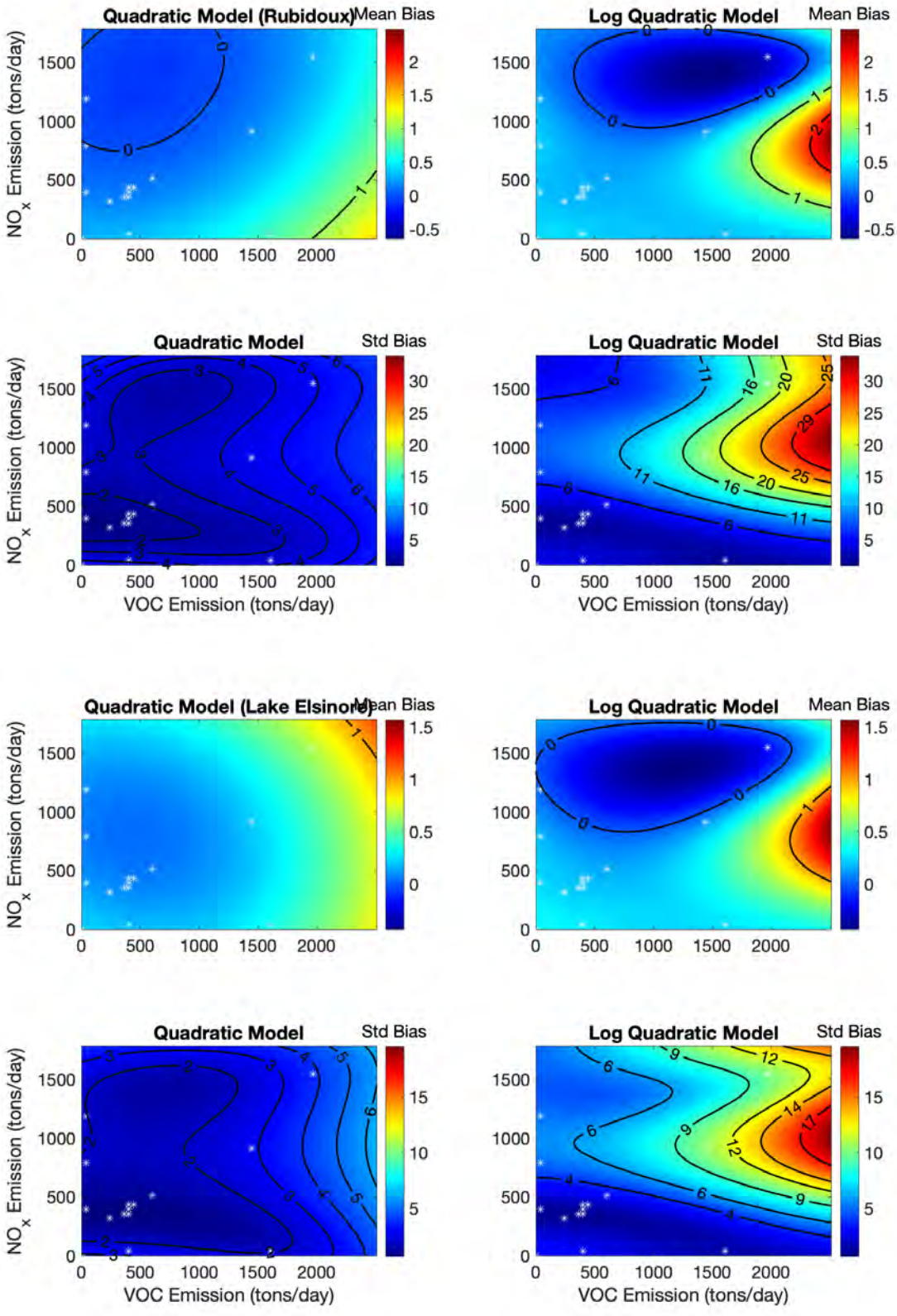

Quadratic Model (Pomona)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (Pasadena)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000

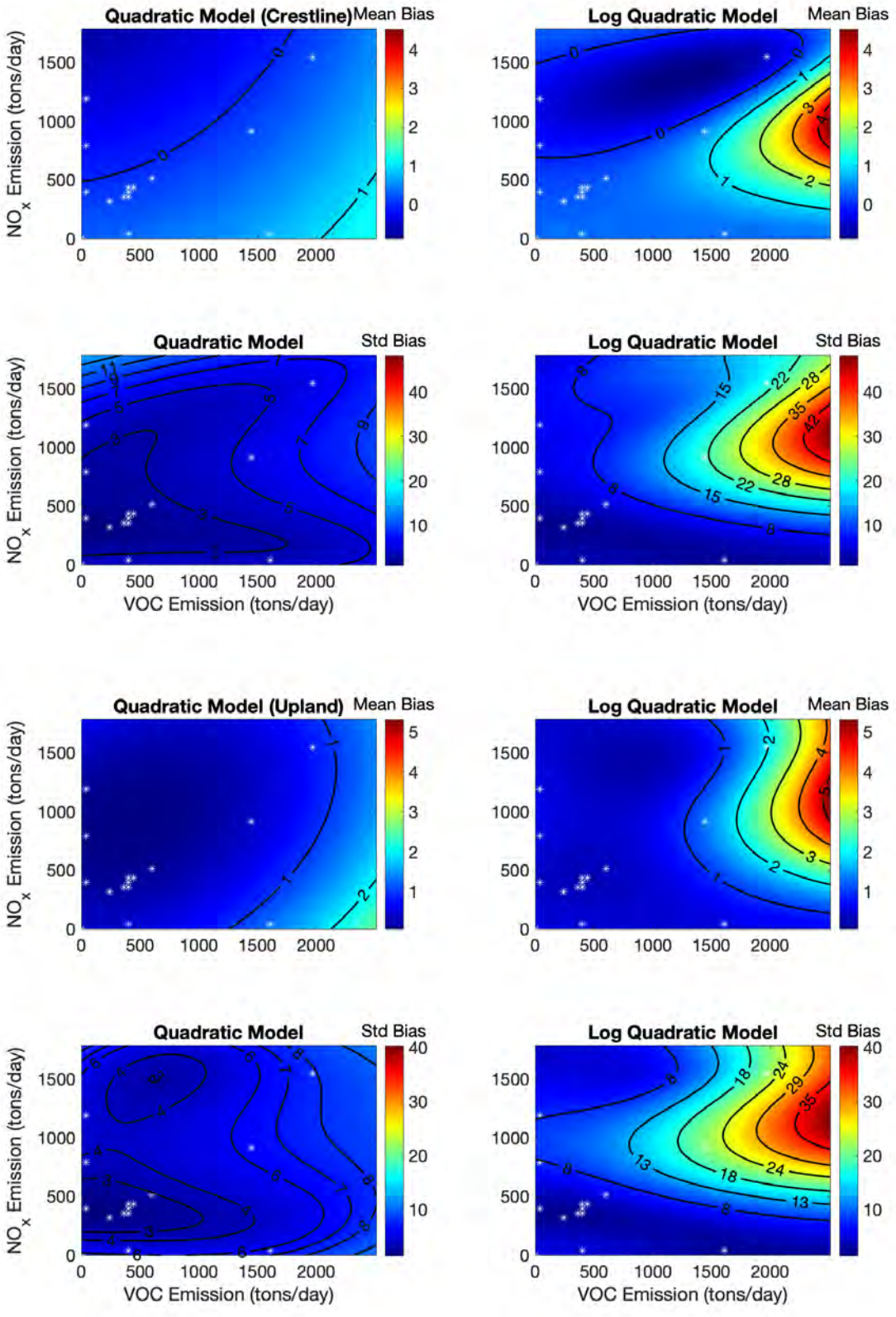

Quadratic Model (Long Beach)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (LAX)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000

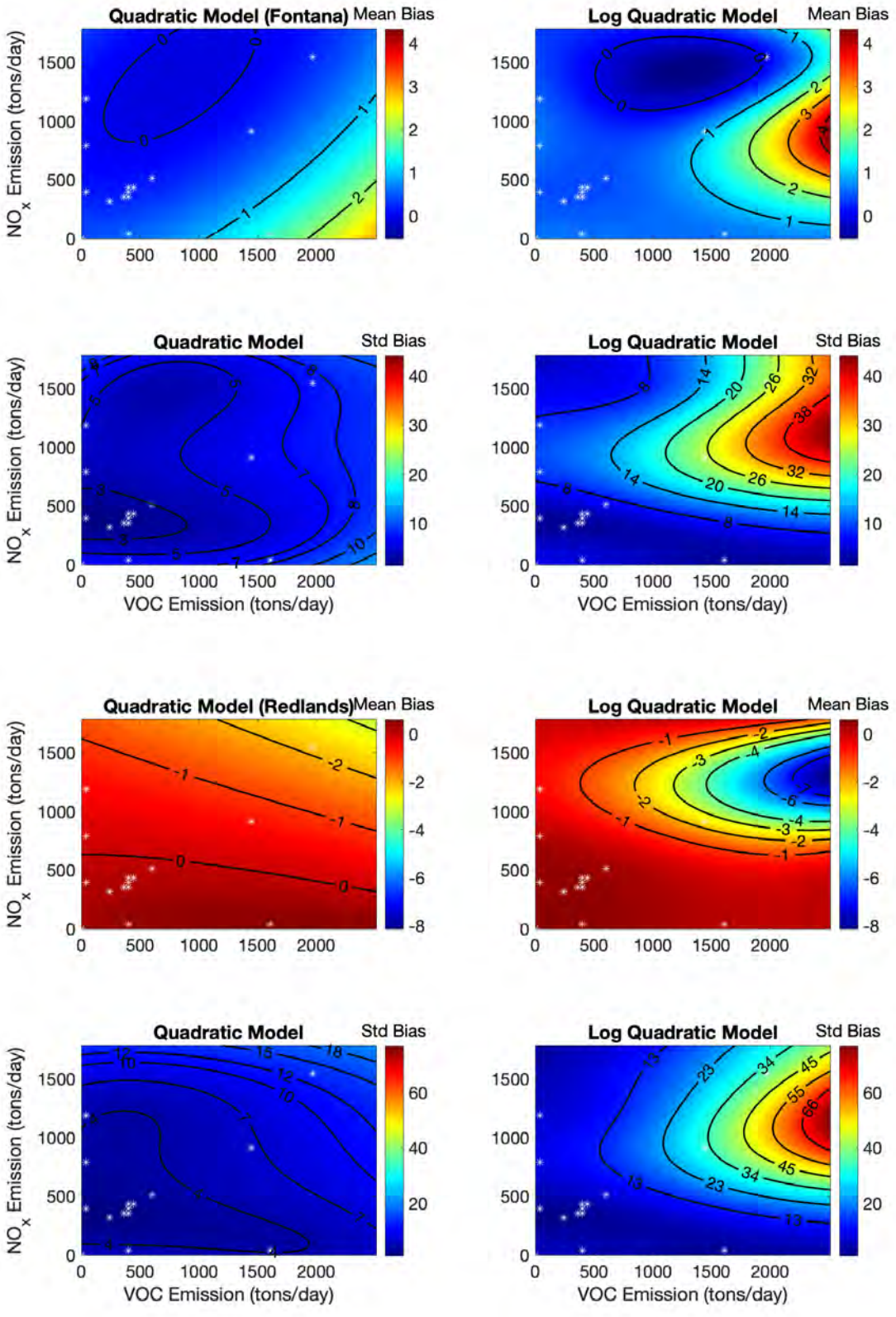

Quadratic Model (Santa Clarita)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (Anaheim)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000

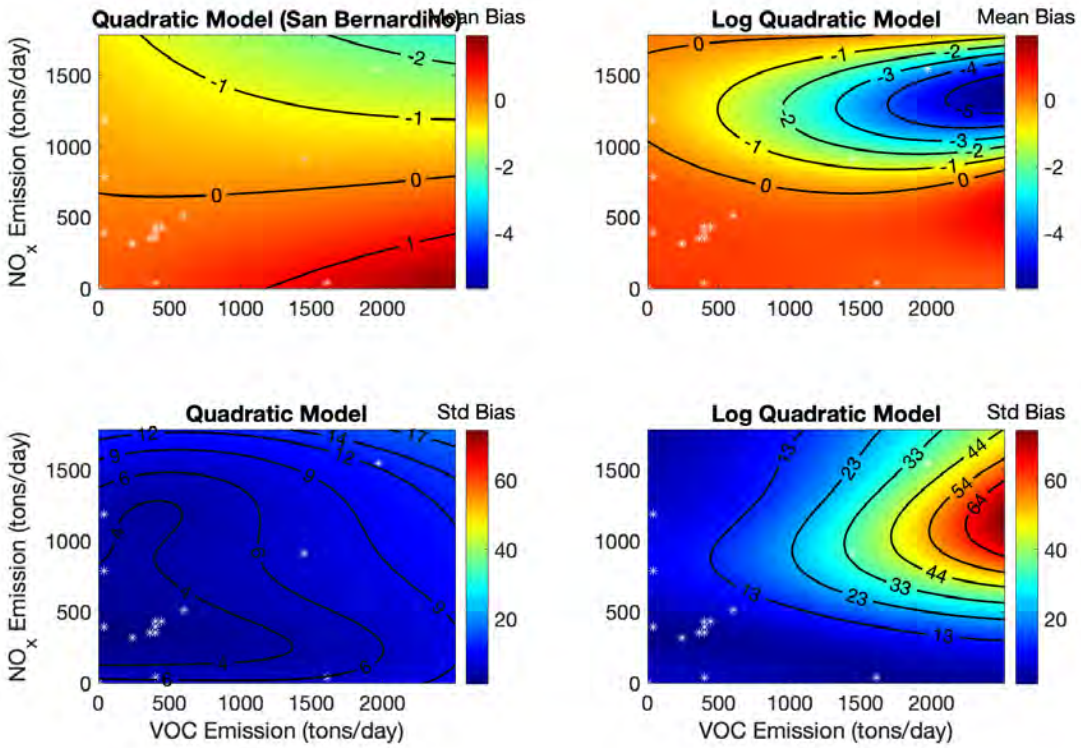

Quadratic Model (Mission Viejo)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (La Habra)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000


Quadratic Model (Banning) Mean Bias
Log Quadratic Model Mean Bias
Quadratic Model Std Bias
Log Quadratic Model Std Bias
Quadratic Model (Perris) Mean Bias
Log Quadratic Model Mean Bias
Quadratic Model Std Bias
Log Quadratic Model Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000
0
1
2
3
5
10
15
20
0.5
-0.5
-1
-1.5


Quadratic Model (Rubidoux)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (Lake Elsinore)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000


Quadratic Model (Crestline)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
Quadratic Model (Upland)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000


Quadratic Model (Fontana) Mean Bias
Log Quadratic Model Mean Bias
Quadratic Model Std Bias
Log Quadratic Model Std Bias
Quadratic Model (Redlands) Mean Bias
Log Quadratic Model Mean Bias
Quadratic Model Std Bias
Log Quadratic Model Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000


Quadratic Model (San Bernardino)
Mean Bias
Log Quadratic Model
Mean Bias
Quadratic Model
Std Bias
Log Quadratic Model
Std Bias
NOx Emission (tons/day)
VOC Emission (tons/day)
0
500
1000
1500
2000
-4
-2
0
20
40
60

Appendix H: Comparison of Ozone Concentration and Sensitivities between CMAQ-HDDM Simulation and Square-root Inverse Distance Weighted (SRIDW) Method-based Isopleth Estimation

Another analysis to evaluate the isopleth uncertainty is to compare the isopleth-calculated ozone concentration and sensitivities at the reference point against the CMAQ-modeled ozone concentration and sensitivities by site, where R^2 is provided. Here we show the comparison results based on the square-root inverse distance weighted method for each individual monitoring site.

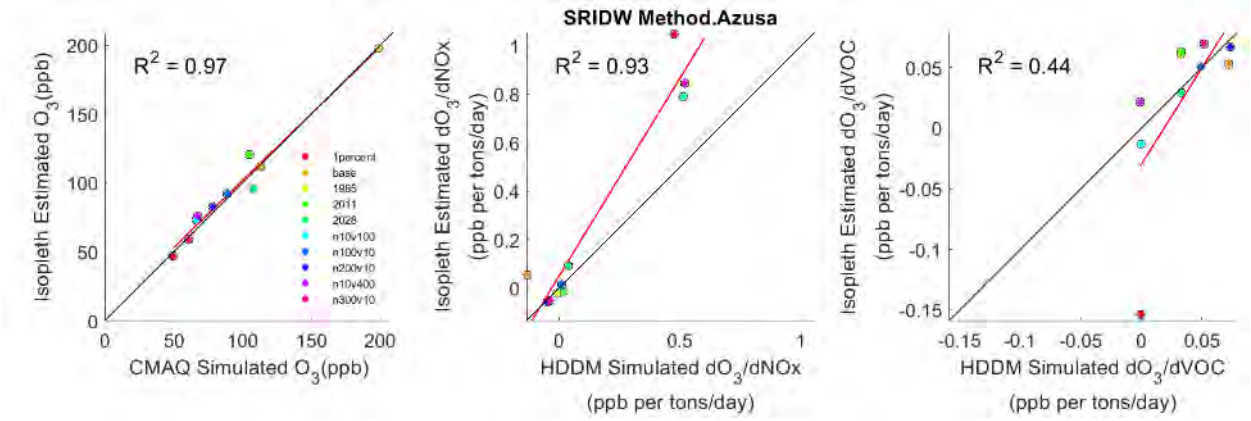
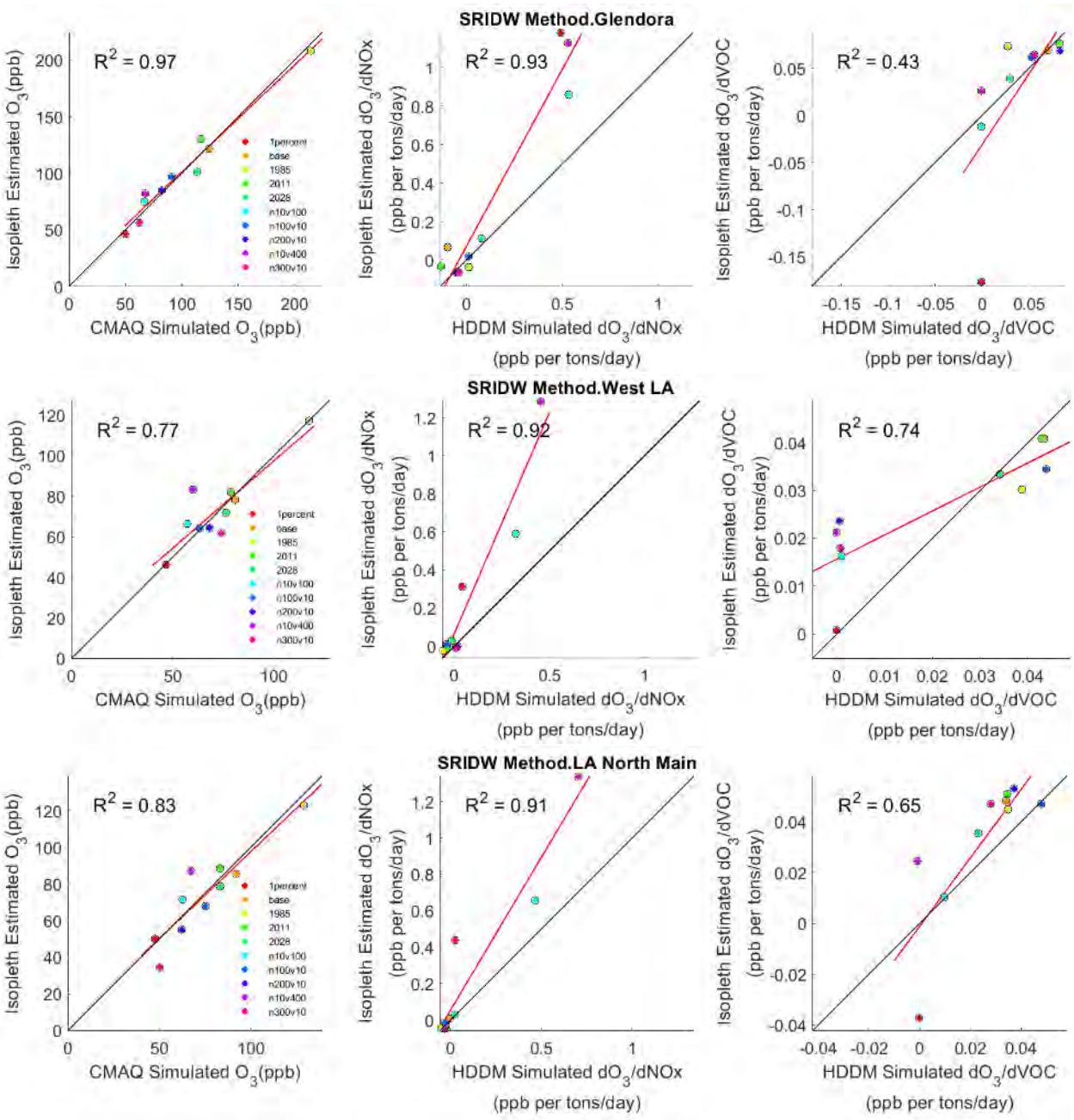
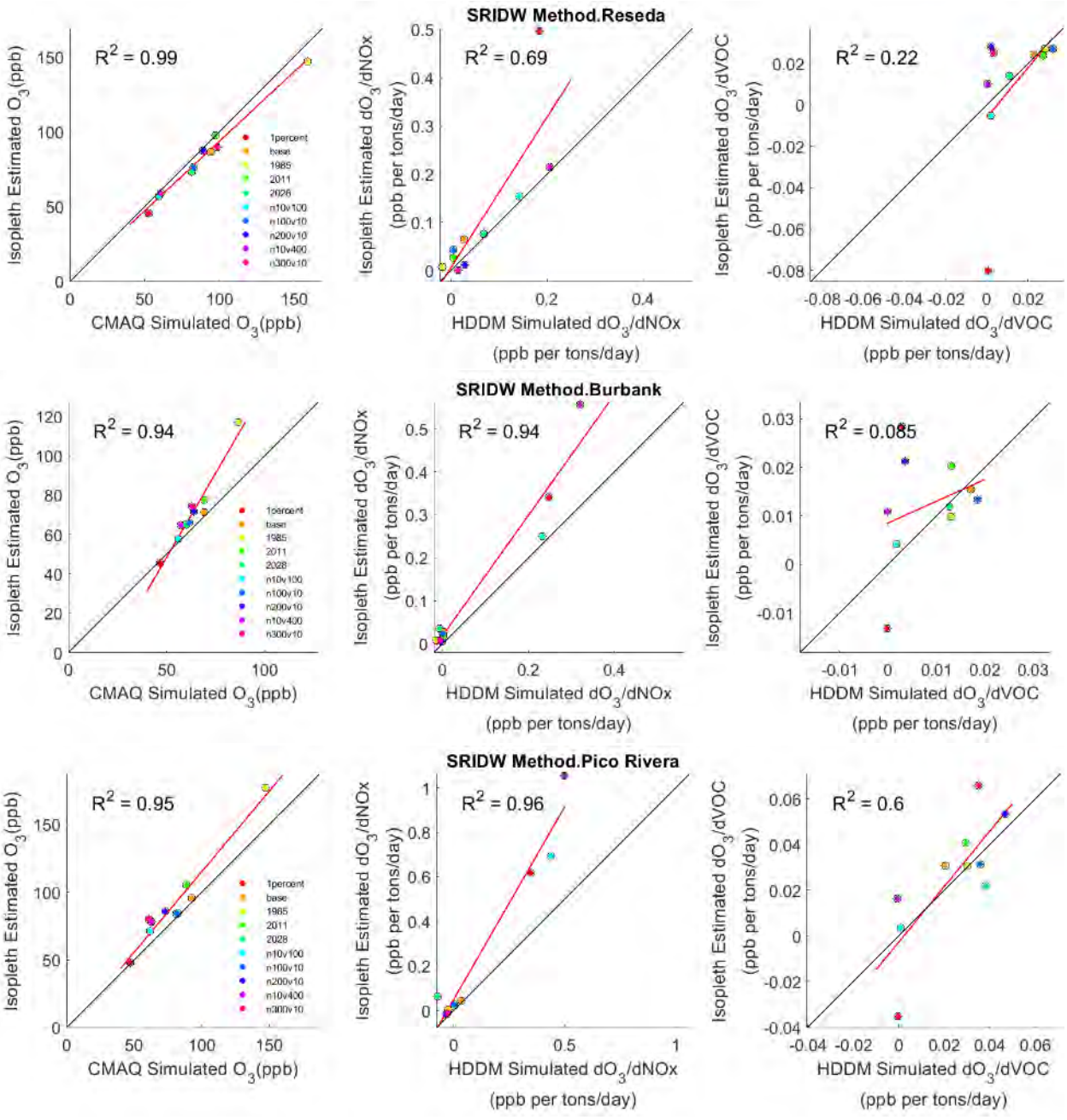
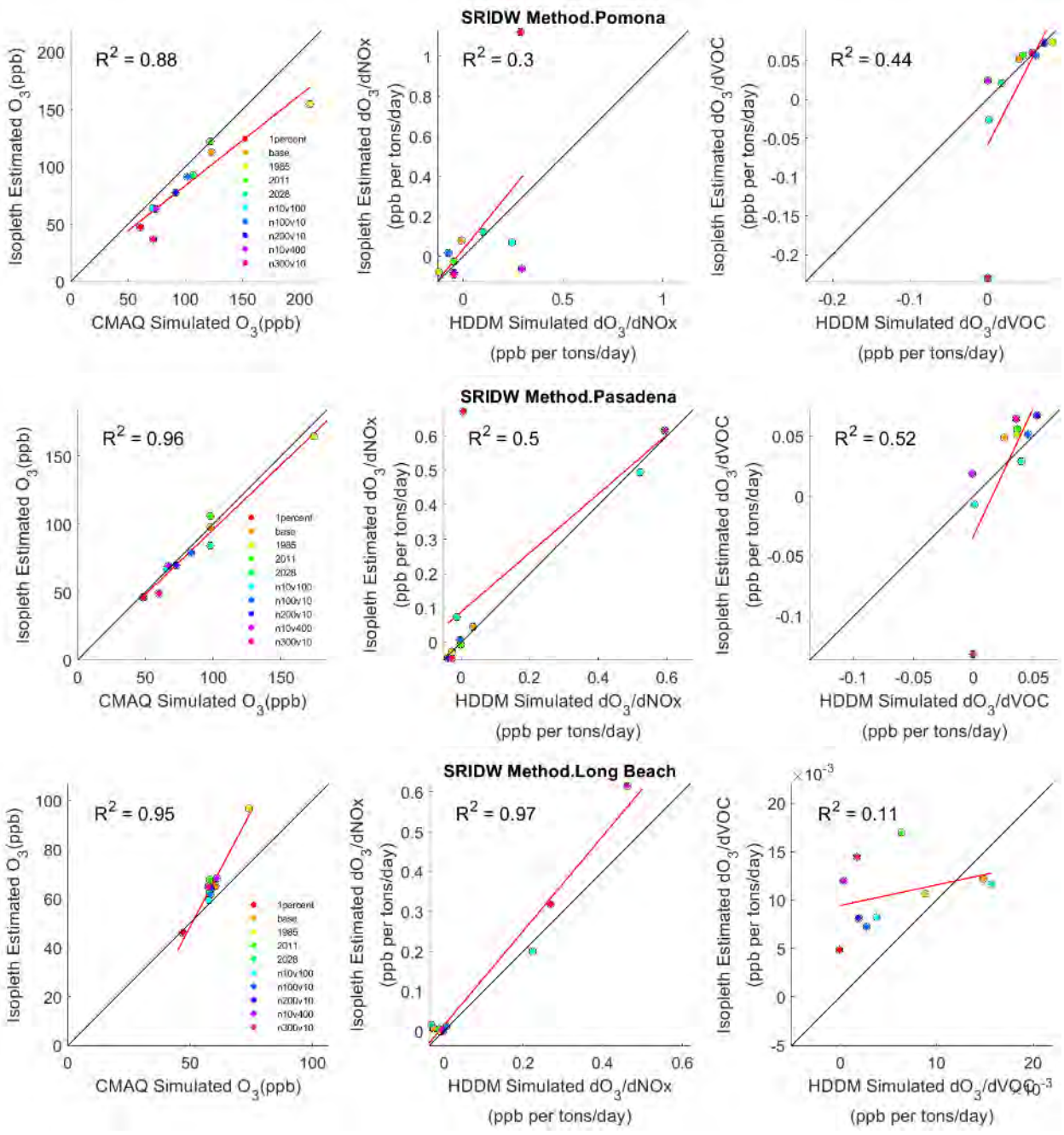
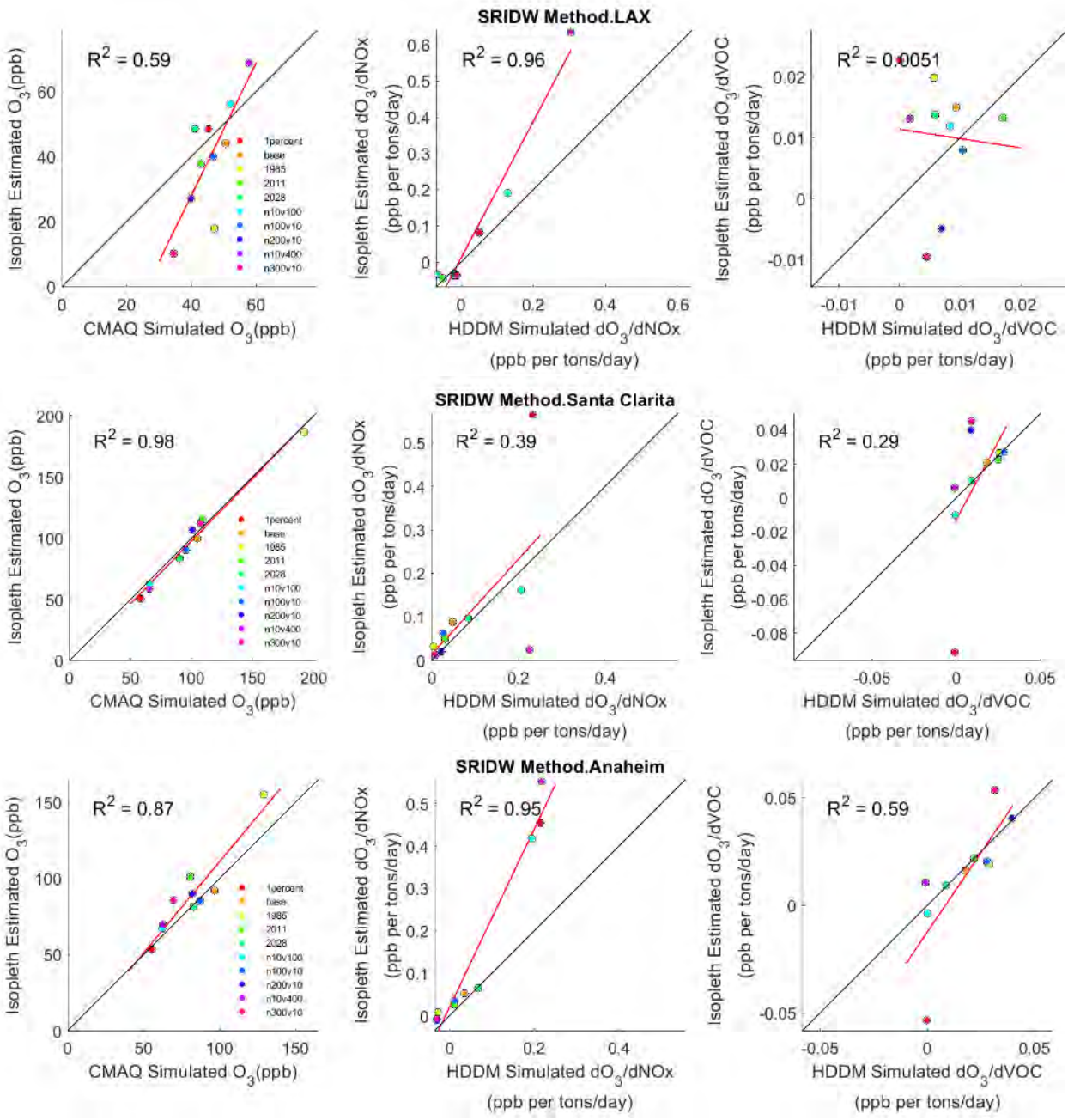


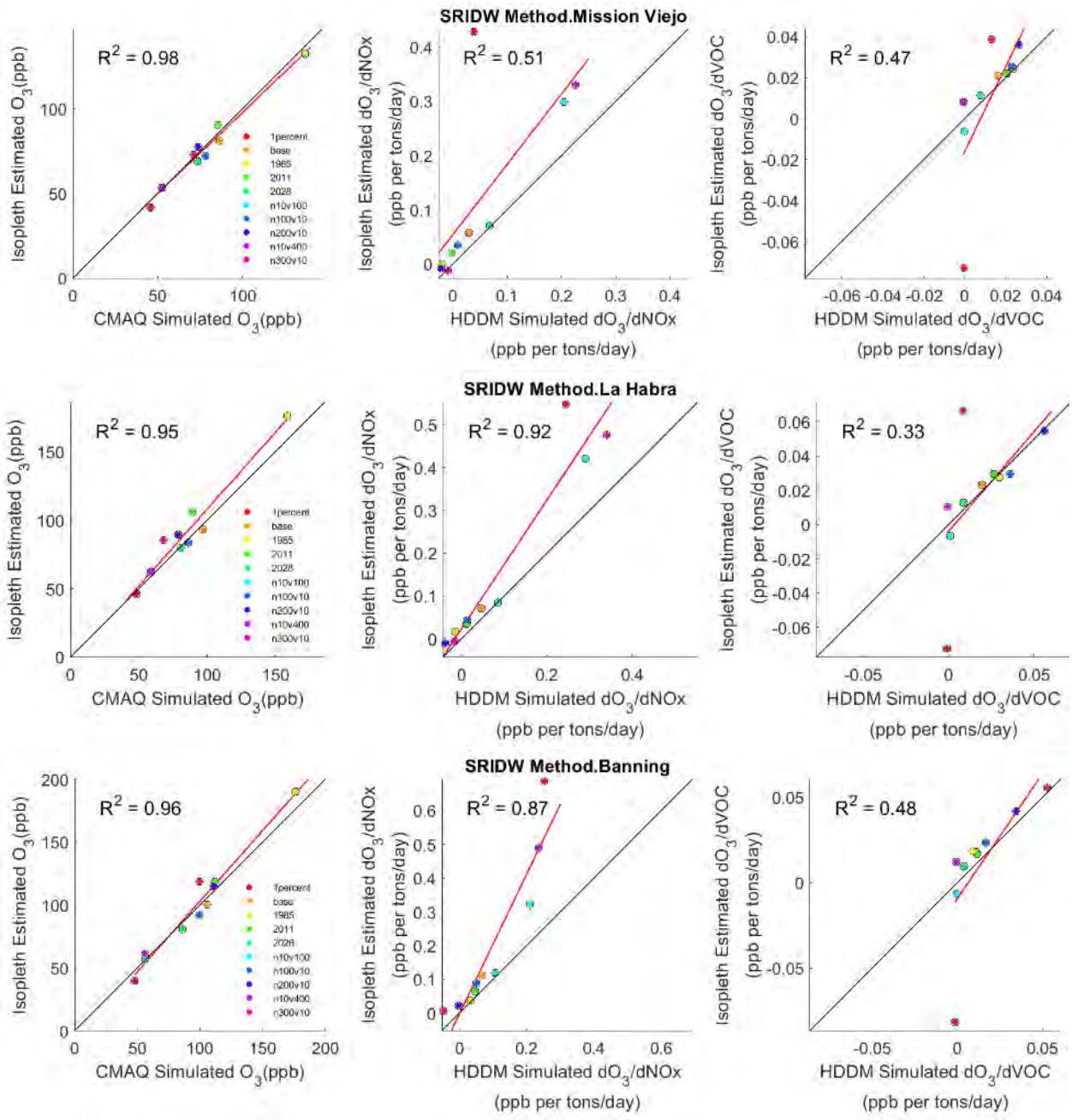
Figure H.1 Comparison of ozone concentration (left) and sensitivities (middle: $dO_3/dNOx$; right: $dO_3/dVOC$) between isopleth estimation based on SRIDW method and CMAQ-HDDM simulation. Results for other sites shown below in this section follow the same layout.

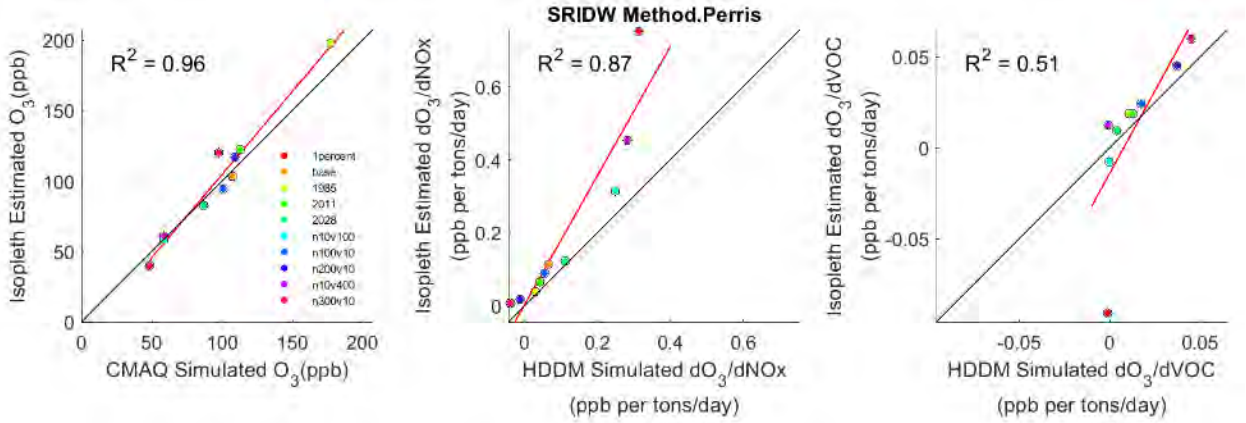

SRIDW Method.Glendora
SRIDW Method.West LA
SRIDW Method.LA North Main
R2 = 0.97
R2 = 0.93
R2 = 0.43
R2 = 0.77
R2 = 0.92
R2 = 0.74
R2 = 0.83
R2 = 0.91
R2 = 0.65
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10

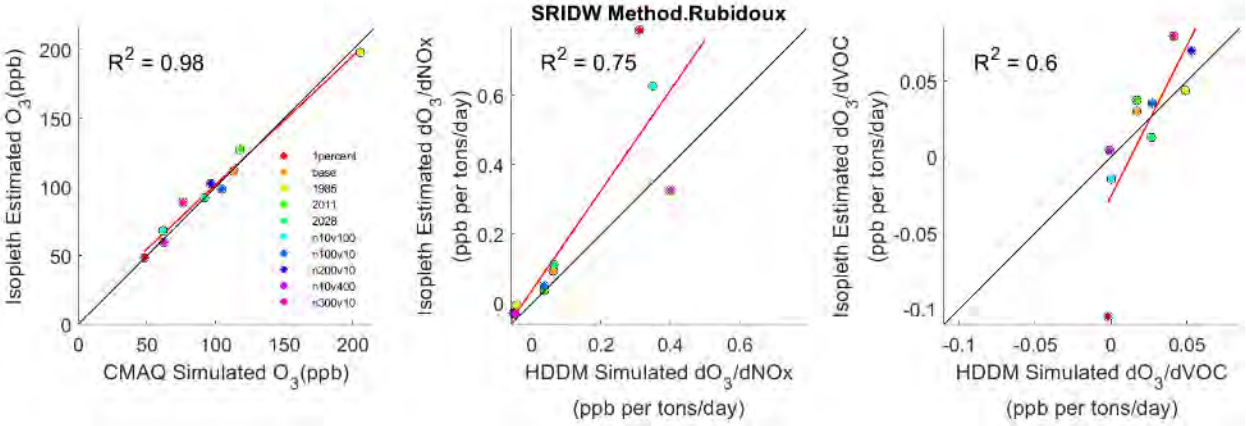

SRIDW Method.Reseda
R² = 0.99
R² = 0.69
R² = 0.22
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10
SRIDW Method.Burbank
R² = 0.94
R² = 0.94
R² = 0.085
SRIDW Method.Pico Rivera
R² = 0.95
R² = 0.96
R² = 0.6

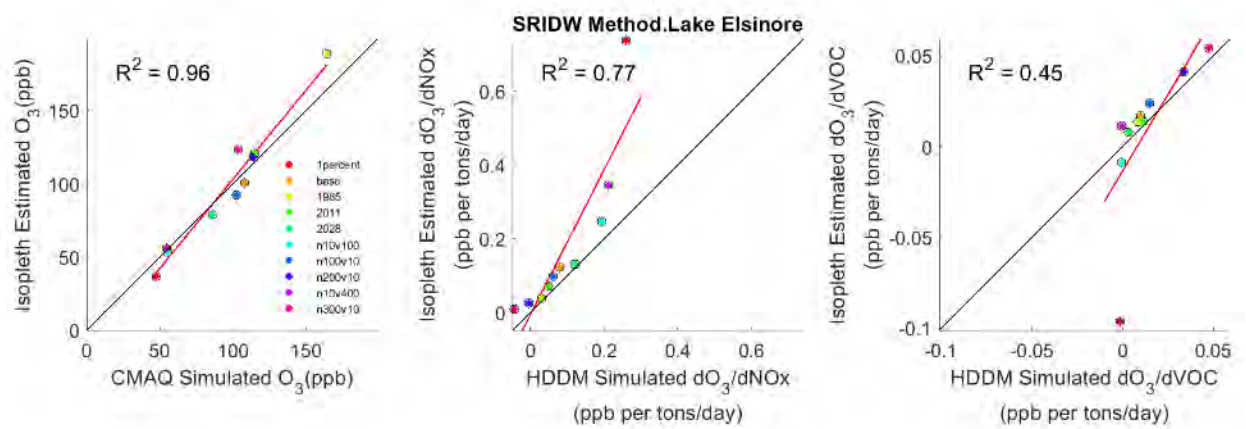

SRIDW Method.Pomona
R2 = 0.88
R2 = 0.3
R2 = 0.44
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10
SRIDW Method.Pasadena
R2 = 0.96
R2 = 0.5
R2 = 0.52
SRIDW Method.Long Beach
R2 = 0.95
R2 = 0.97
R2 = 0.11
×10-3

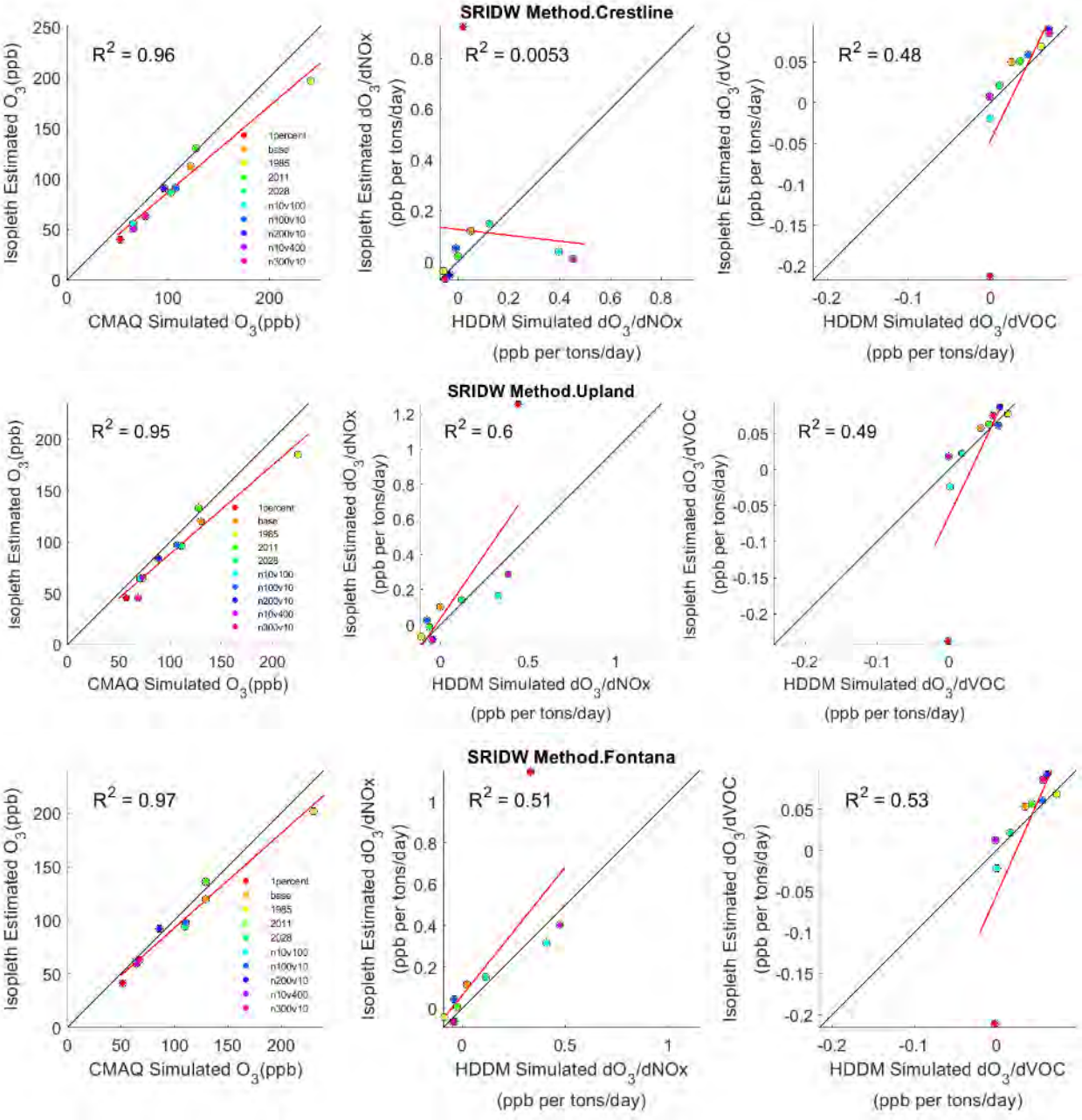

SRIDW Method.LAX
R2 = 0.59
R2 = 0.96
R2 = 0.0051
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10
SRIDW Method.Santa Clarita
R2 = 0.98
R2 = 0.39
R2 = 0.29
SRIDW Method.Anaheim
R2 = 0.87
R2 = 0.95
R2 = 0.59

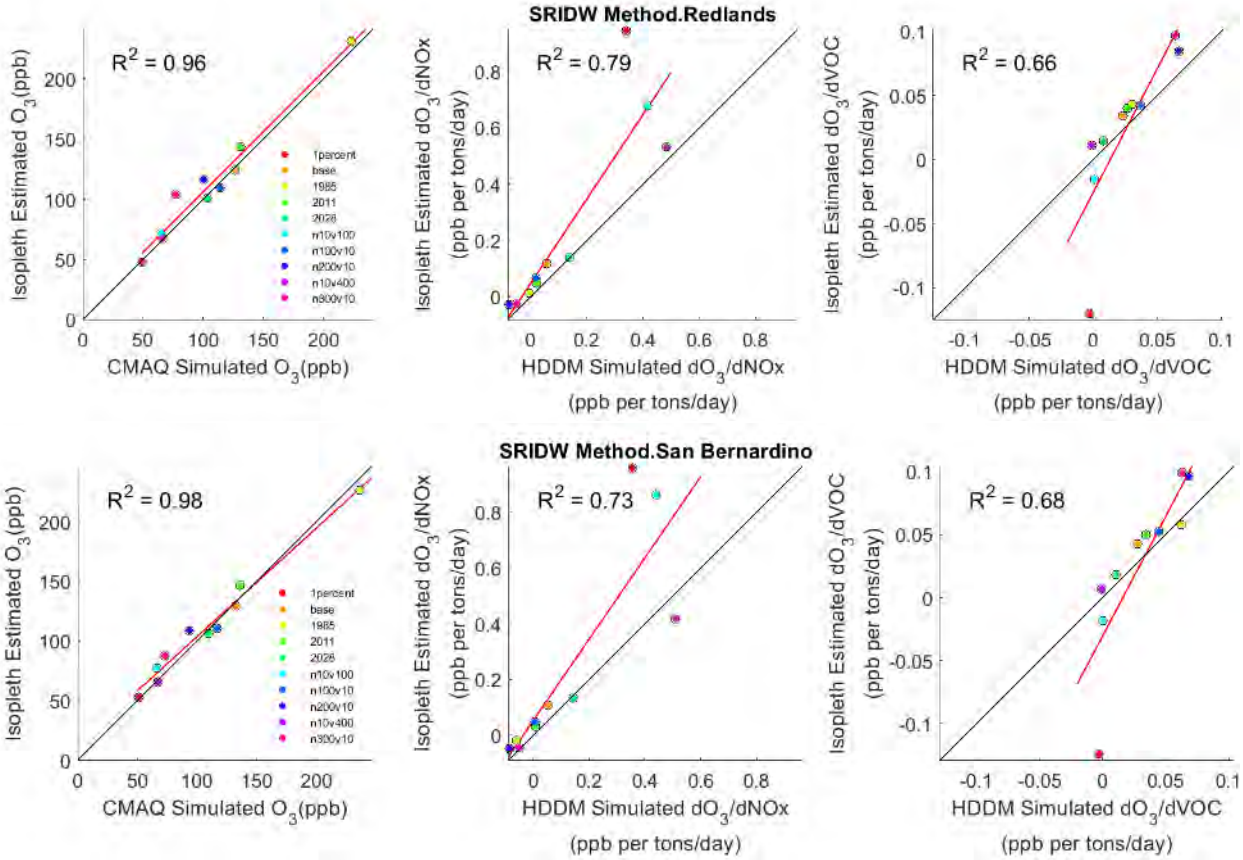

SRIDW Method.Mission Viejo
R2 = 0.98
R2 = 0.51
R2 = 0.47
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10
SRIDW Method.La Habra
R2 = 0.95
R2 = 0.92
R2 = 0.33
SRIDW Method.Banning
R2 = 0.96
R2 = 0.87
R2 = 0.48


SRIDW Method.Perris
R2 = 0.96
R2 = 0.87
R2 = 0.51
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10


SRIDW Method.Rubidoux
R2 = 0.98
R2 = 0.75
R2 = 0.6
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10


SRIDW Method.Lake Elsinore
R2 = 0.96
R2 = 0.77
R2 = 0.45
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10


SRIDW Method.Crestline
SRIDW Method.Upland
SRIDW Method.Fontana
R2 = 0.96
R2 = 0.0053
R2 = 0.48
R2 = 0.95
R2 = 0.6
R2 = 0.49
R2 = 0.97
R2 = 0.51
R2 = 0.53
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2028
n10v100
n100v10
n200v10
n10v400
n300v10


SRIDW Method.Redlands
R² = 0.96
R² = 0.79
R² = 0.66
Isopleth Estimated O3(ppb)
CMAQ Simulated O3(ppb)
Isopleth Estimated dO3/dNOx (ppb per tons/day)
HDDM Simulated dO3/dNOx (ppb per tons/day)
Isopleth Estimated dO3/dVOC (ppb per tons/day)
HDDM Simulated dO3/dVOC (ppb per tons/day)
1percent
base
1985
2011
2026
n10v100
n100v10
n200v10
n10v400
n300v10
SRIDW Method.San Bernardino
R² = 0.98
R² = 0.73
R² = 0.68

Appendix I: Comparison of Ozone Concentration and Sensitivities between CMAQ-HDDM Simulation and Quadratic-fitting-method-based Isopleth Estimation

Another analysis to evaluate the isopleth uncertainty is to compare the isopleth-calculated ozone concentration and sensitivities at the reference point against the CMAQ-modeled ozone concentration and sensitivities by site, where R^2 is provided. Here we show the comparison results based on the quadratic-fitting method for each individual monitoring site.

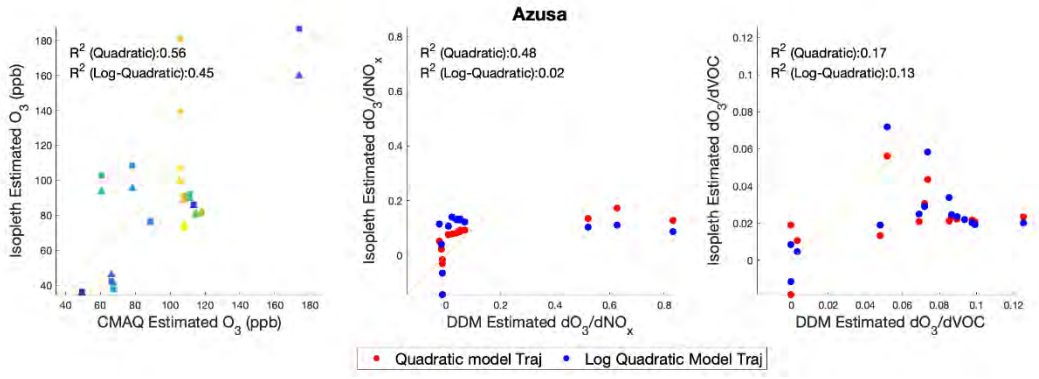
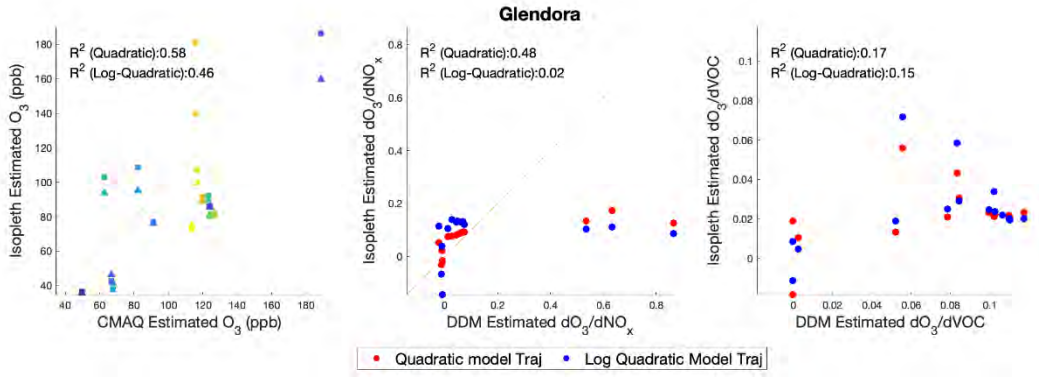
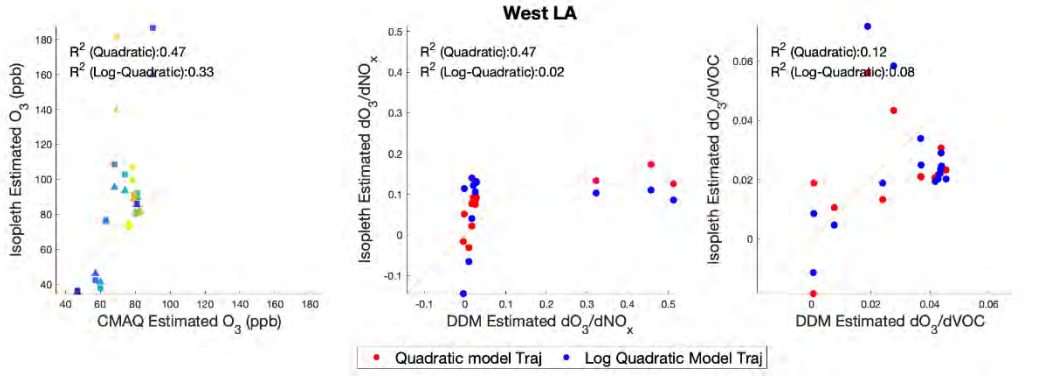
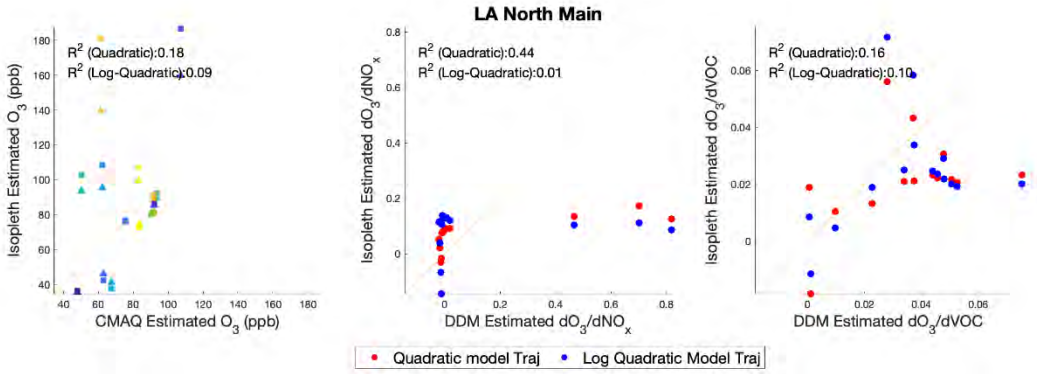
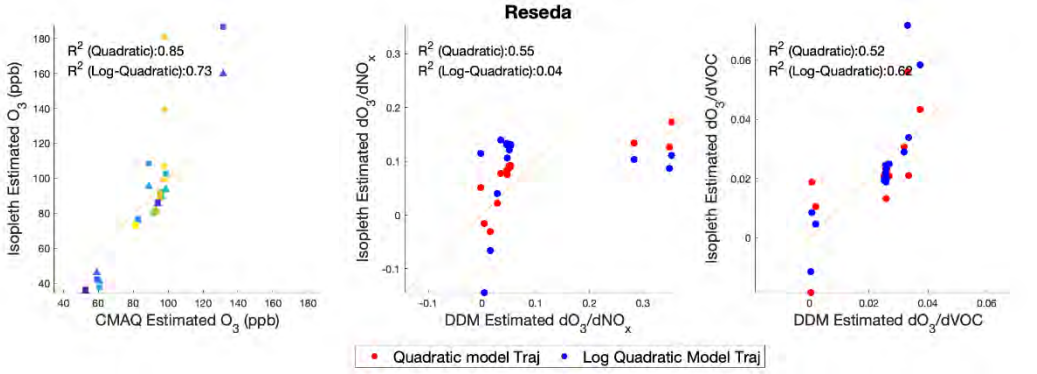


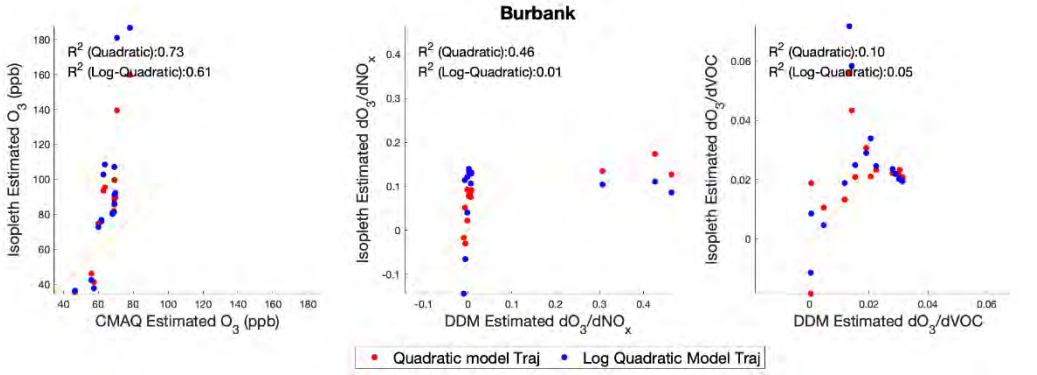
Figure I.1 Comparison of ozone concentration (left) and sensitivities (middle: $dO_3/dNOx$; right: $dO_3/dVOC$) between isopleth estimation based on quadratic-fitting method and CMAQ-HDDM simulation. Results for other sites shown below in this section follow the same layout.

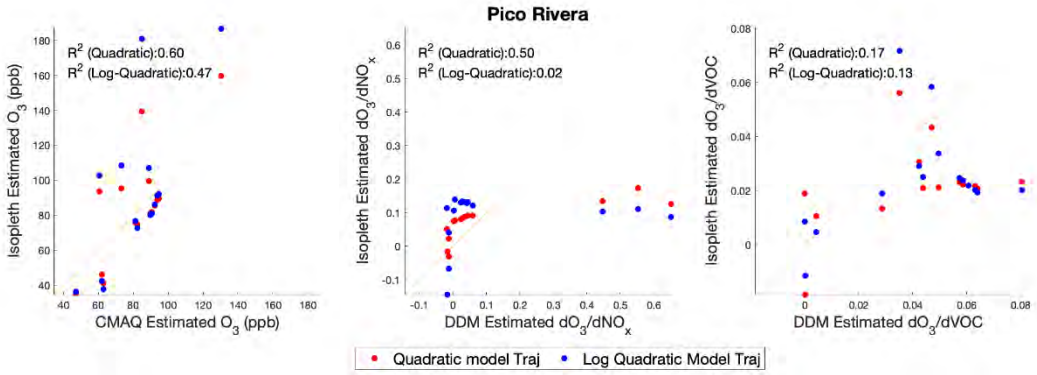


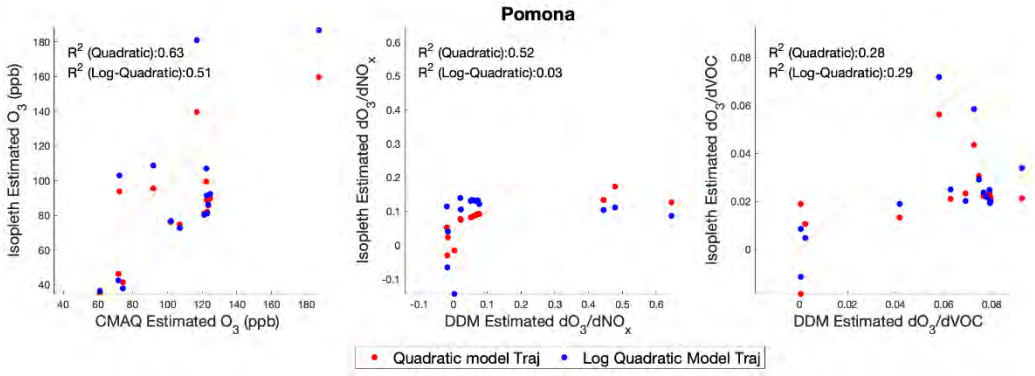


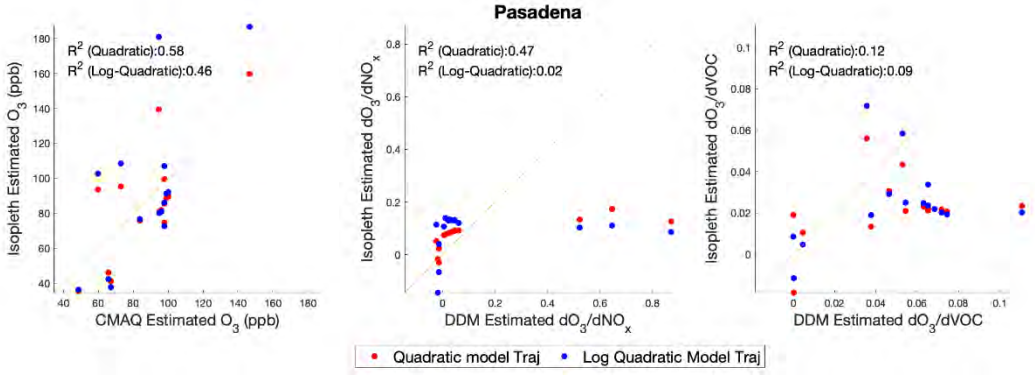

LA North Main
R² (Quadratic):0.18
R² (Log-Quadratic):0.09
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.44
R² (Log-Quadratic):0.01
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.16
R² (Log-Quadratic):0.10
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

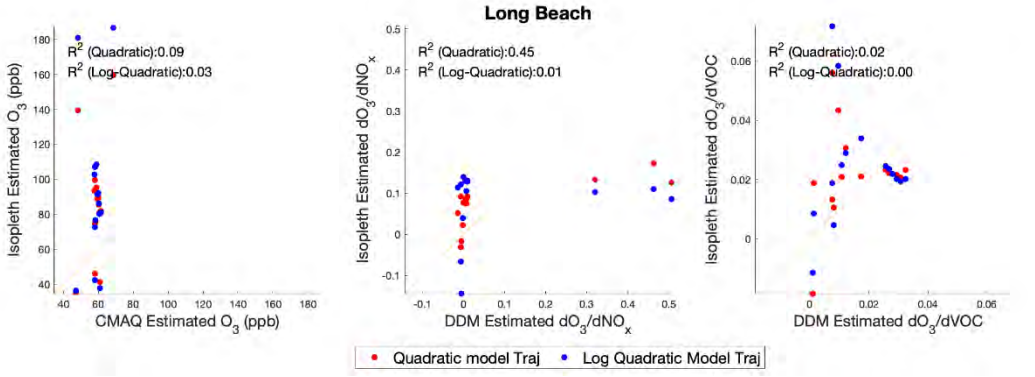

Reseda
R² (Quadratic):0.85
R² (Log-Quadratic):0.73
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.55
R² (Log-Quadratic):0.04
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.52
R² (Log-Quadratic):0.62
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

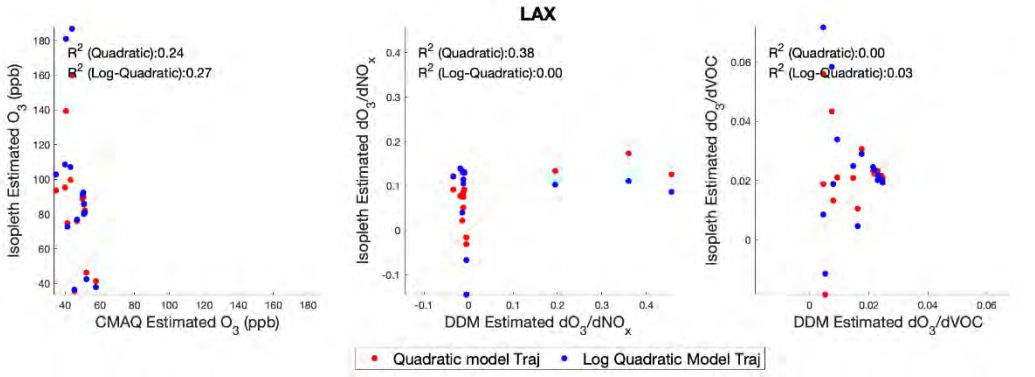

Burbank
R² (Quadratic):0.73
R² (Log-Quadratic):0.61
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.46
R² (Log-Quadratic):0.01
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.10
R² (Log-Quadratic):0.05
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

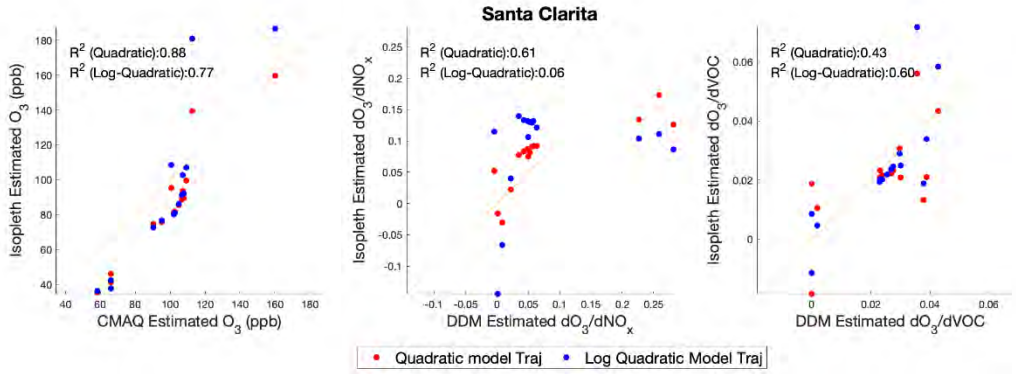

Pico Rivera
R² (Quadratic):0.60
R² (Log-Quadratic):0.47
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.50
R² (Log-Quadratic):0.02
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.17
R² (Log-Quadratic):0.13
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

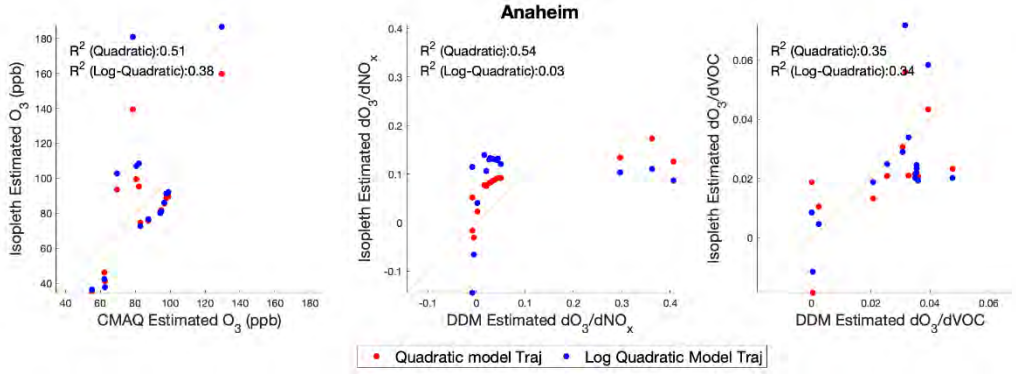

Pomona
R2 (Quadratic):0.63
R2 (Log-Quadratic):0.51
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.52
R2 (Log-Quadratic):0.03
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R2 (Quadratic):0.28
R2 (Log-Quadratic):0.29
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

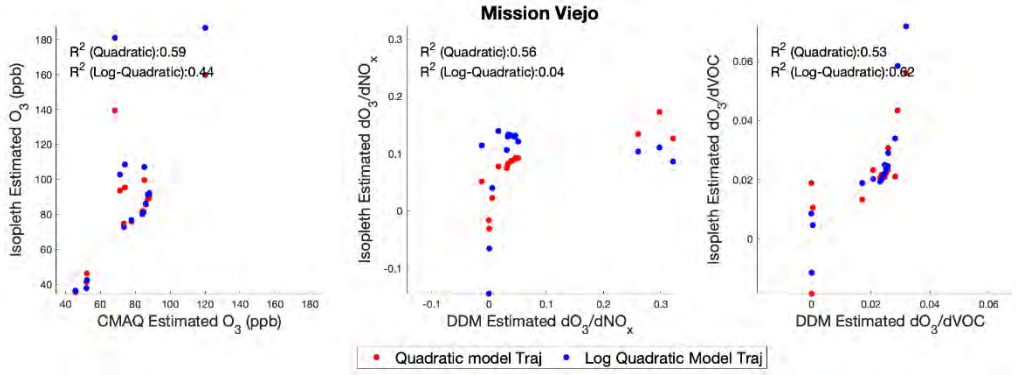

Pasadena
R2 (Quadratic):0.58
R2 (Log-Quadratic):0.46
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.47
R2 (Log-Quadratic):0.02
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R2 (Quadratic):0.12
R2 (Log-Quadratic):0.09
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

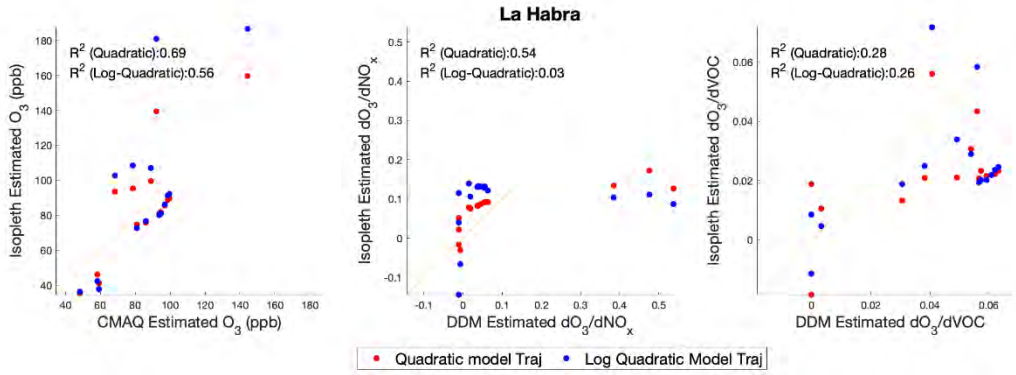

Long Beach
R2 (Quadratic):0.09
R2 (Log-Quadratic):0.03
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.45
R2 (Log-Quadratic):0.01
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R2 (Quadratic):0.02
R2 (Log-Quadratic):0.00
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

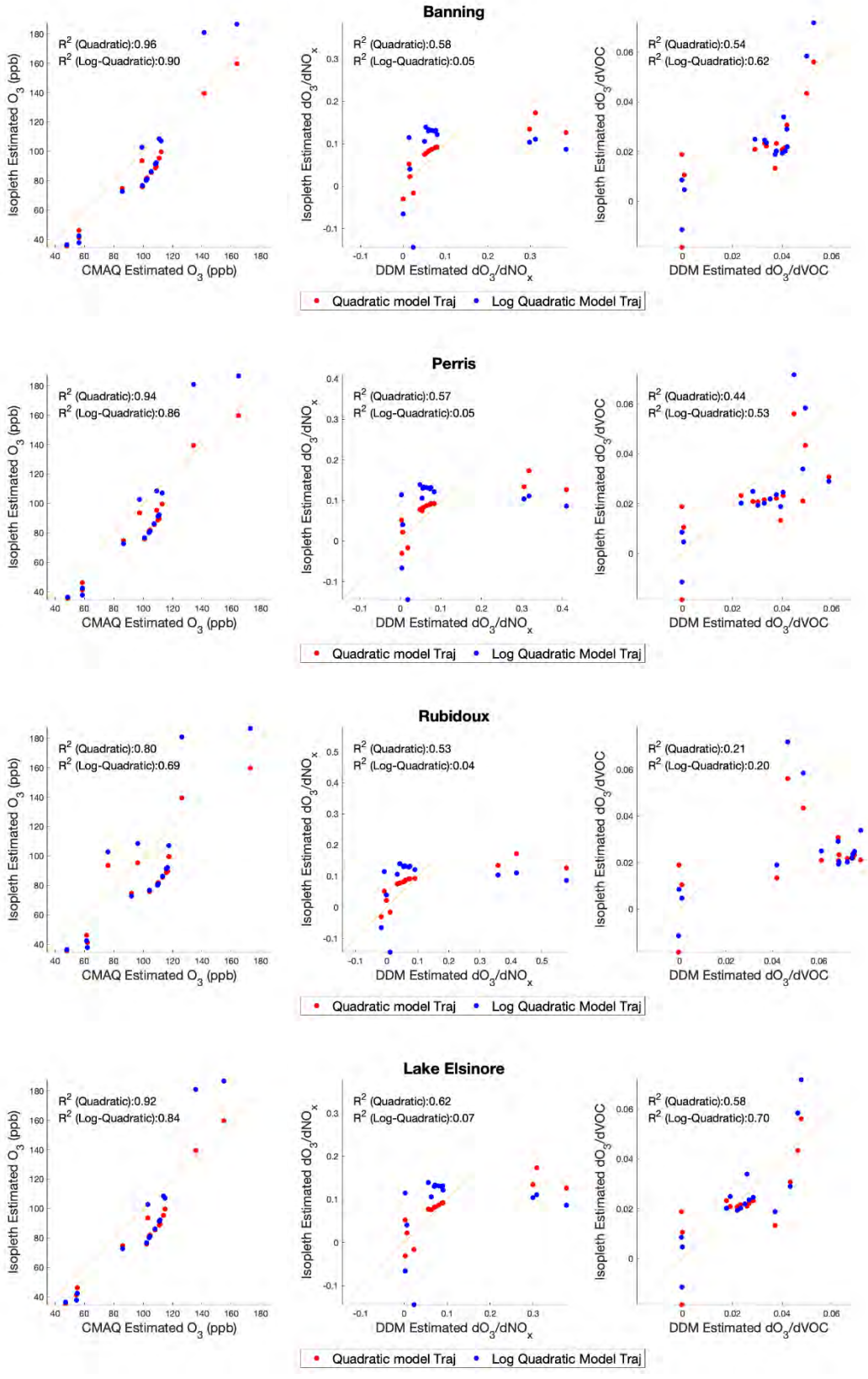

LAX
R2 (Quadratic):0.24
R2 (Log-Quadratic):0.27
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.38
R2 (Log-Quadratic):0.00
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R2 (Quadratic):0.00
R2 (Log-Quadratic):0.03
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

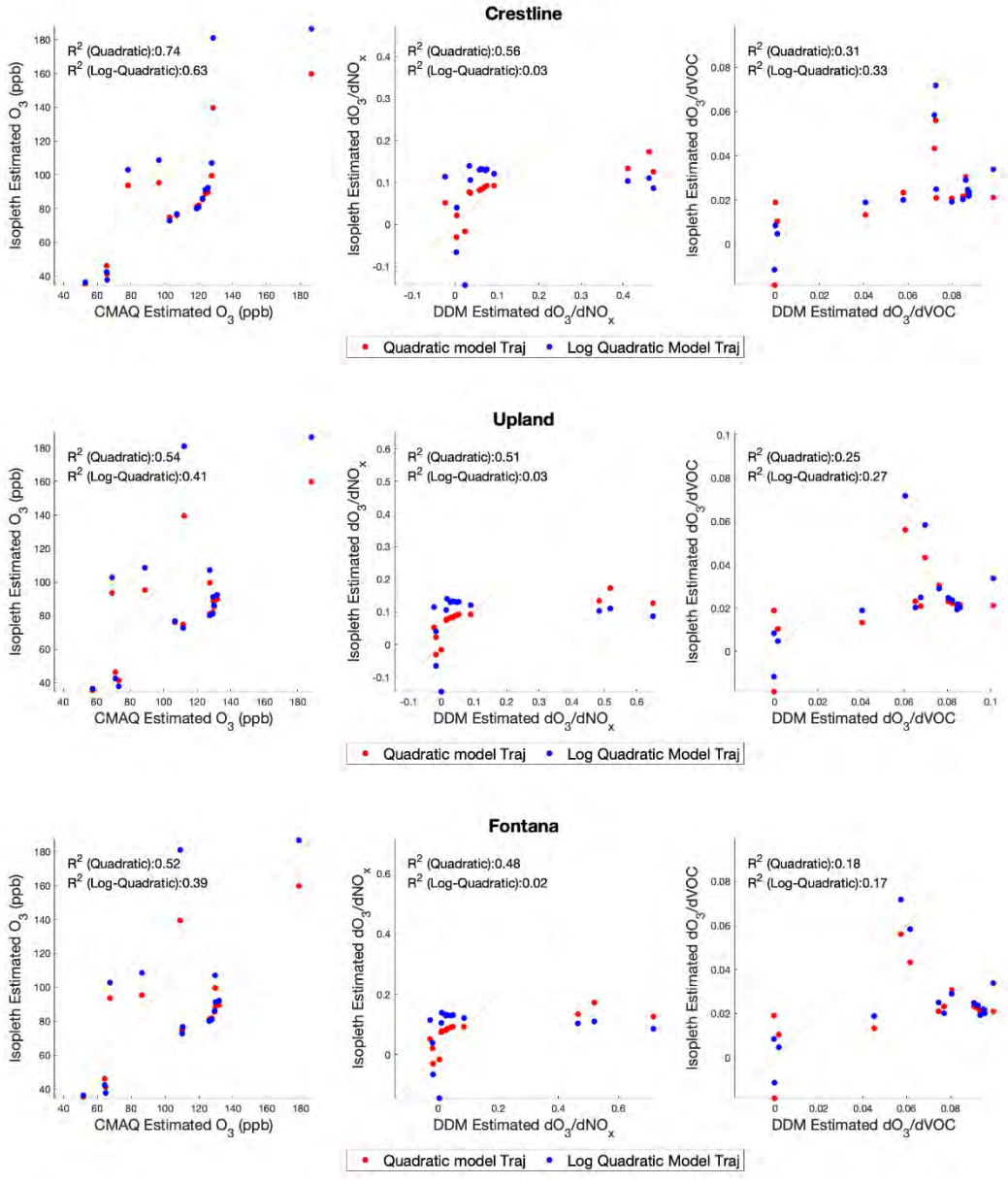

Santa Clarita
R² (Quadratic):0.88
R² (Log-Quadratic):0.77
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.61
R² (Log-Quadratic):0.06
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.43
R² (Log-Quadratic):0.60
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

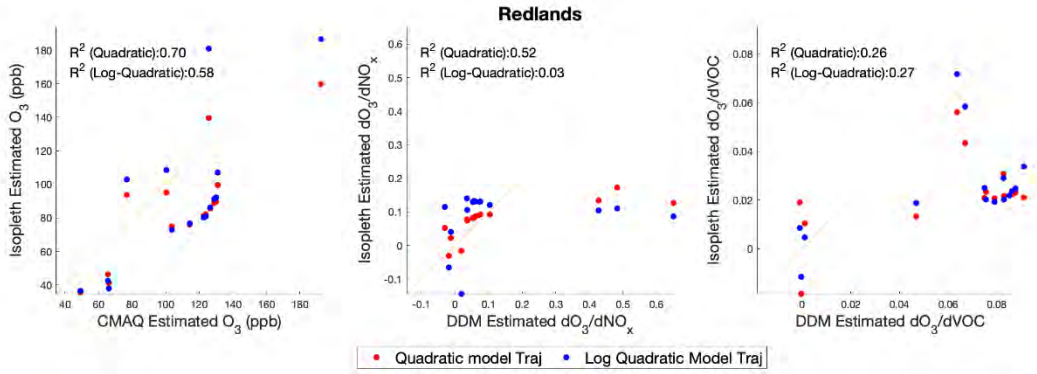

Anaheim
R² (Quadratic):0.51
R² (Log-Quadratic):0.38
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.54
R² (Log-Quadratic):0.03
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.35
R² (Log-Quadratic):0.34
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

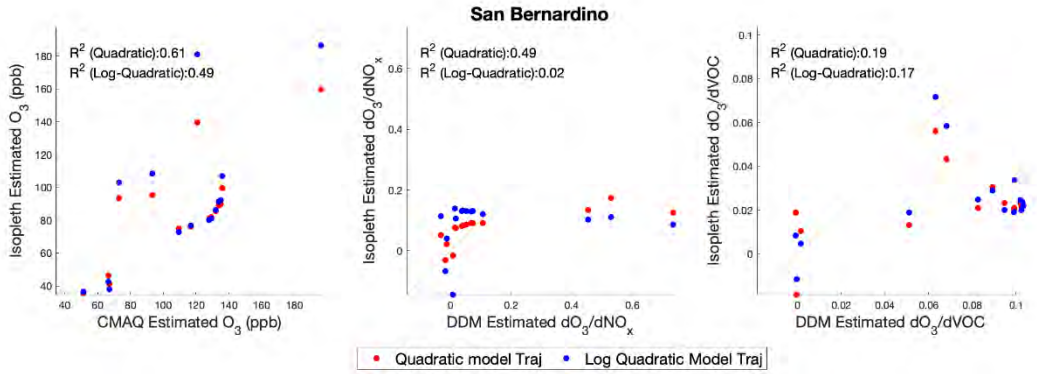

Mission Viejo
R² (Quadratic):0.59
R² (Log-Quadratic):0.44
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.56
R² (Log-Quadratic):0.04
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.53
R² (Log-Quadratic):0.62
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj


La Habra
R² (Quadratic):0.69
R² (Log-Quadratic):0.56
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.54
R² (Log-Quadratic):0.03
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.28
R² (Log-Quadratic):0.26
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj


Banning
R² (Quadratic):0.96
R² (Log-Quadratic):0.90
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.58
R² (Log-Quadratic):0.05
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.54
R² (Log-Quadratic):0.62
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj
Perris
R² (Quadratic):0.94
R² (Log-Quadratic):0.86
R² (Quadratic):0.57
R² (Log-Quadratic):0.05
R² (Quadratic):0.44
R² (Log-Quadratic):0.53
Rubidoux
R² (Quadratic):0.80
R² (Log-Quadratic):0.69
R² (Quadratic):0.53
R² (Log-Quadratic):0.04
R² (Quadratic):0.21
R² (Log-Quadratic):0.20
Lake Elsinore
R² (Quadratic):0.92
R² (Log-Quadratic):0.84
R² (Quadratic):0.62
R² (Log-Quadratic):0.07
R² (Quadratic):0.58
R² (Log-Quadratic):0.70


Crestline
R2 (Quadratic):0.74
R2 (Log-Quadratic):0.63
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.56
R2 (Log-Quadratic):0.03
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R2 (Quadratic):0.31
R2 (Log-Quadratic):0.33
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj
Upland
R2 (Quadratic):0.54
R2 (Log-Quadratic):0.41
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.51
R2 (Log-Quadratic):0.03
DDM Estimated dO3/dNOx
R2 (Quadratic):0.25
R2 (Log-Quadratic):0.27
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj
Fontana
R2 (Quadratic):0.52
R2 (Log-Quadratic):0.39
CMAQ Estimated O3 (ppb)
R2 (Quadratic):0.48
R2 (Log-Quadratic):0.02
DDM Estimated dO3/dNOx
R2 (Quadratic):0.18
R2 (Log-Quadratic):0.17
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj


Redlands
R² (Quadratic):0.70
R² (Log-Quadratic):0.58
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.52
R² (Log-Quadratic):0.03
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.26
R² (Log-Quadratic):0.27
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj


San Bernardino
R² (Quadratic):0.61
R² (Log-Quadratic):0.49
Isopleth Estimated O3 (ppb)
CMAQ Estimated O3 (ppb)
R² (Quadratic):0.49
R² (Log-Quadratic):0.02
Isopleth Estimated dO3/dNOx
DDM Estimated dO3/dNOx
R² (Quadratic):0.19
R² (Log-Quadratic):0.17
Isopleth Estimated dO3/dVOC
DDM Estimated dO3/dVOC
Quadratic model Traj
Log Quadratic Model Traj

Appendix J: Ozone Concentration and Sensitivity Isopleths of Empirical Model, CMAQ-HDDM >odel (Based on the Square-root Inverse Distance Weighted Method (SRIDW)), and the Difference Between Each Other

Developing ozone isopleths provides a direct method for comparing sensitivities between the empirical and CTM-based models. Qualitative approaches for comparing the two include visual inspection of ozone isopleths generated by the square-root inverse distance weighted method and similarly comparing sensitivity isopleths. We show the developed ozone and sensitivity isopleth based on empirical model and CMAQ-HDDM model and the difference between methods for each individual monitoring site.

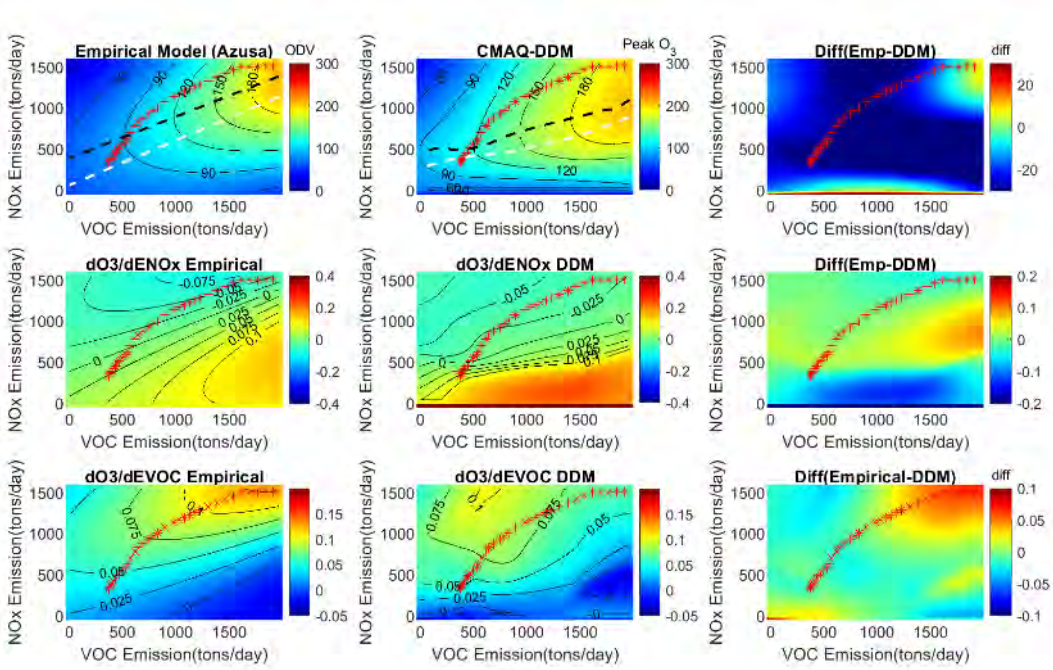
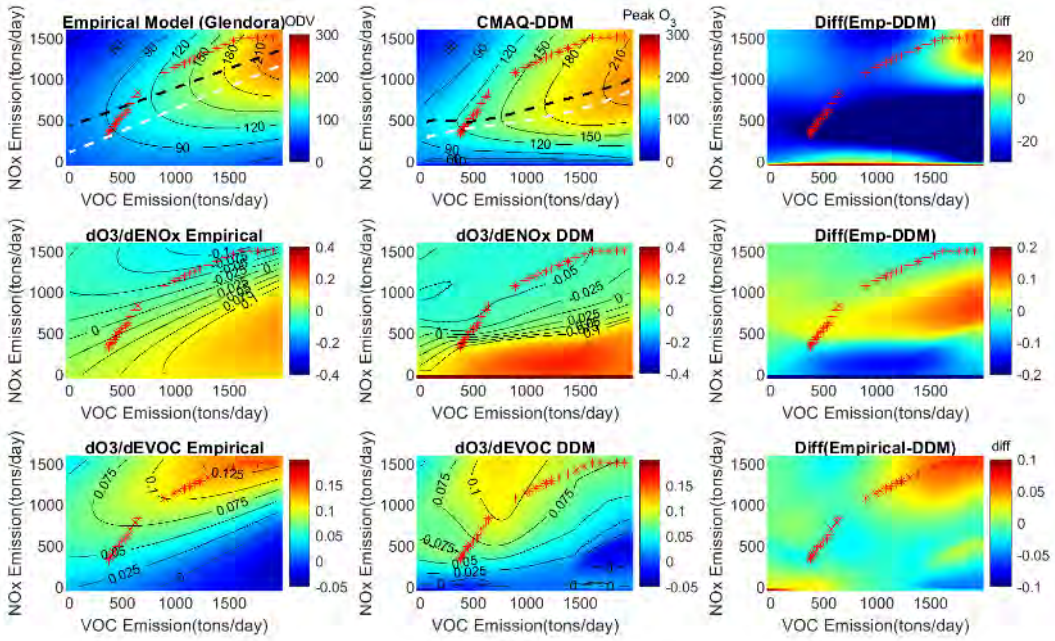
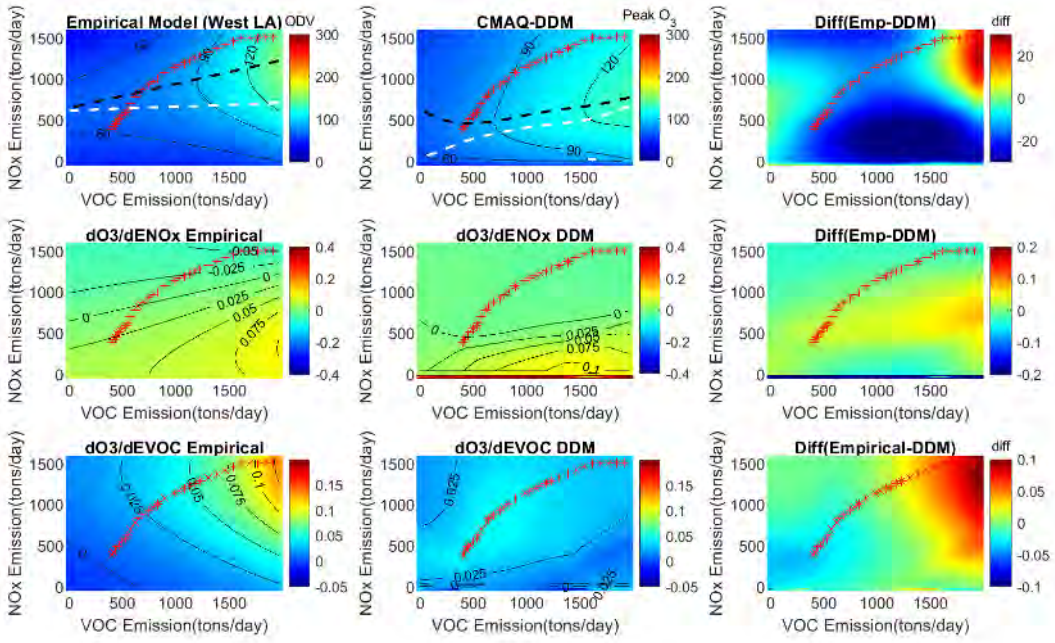
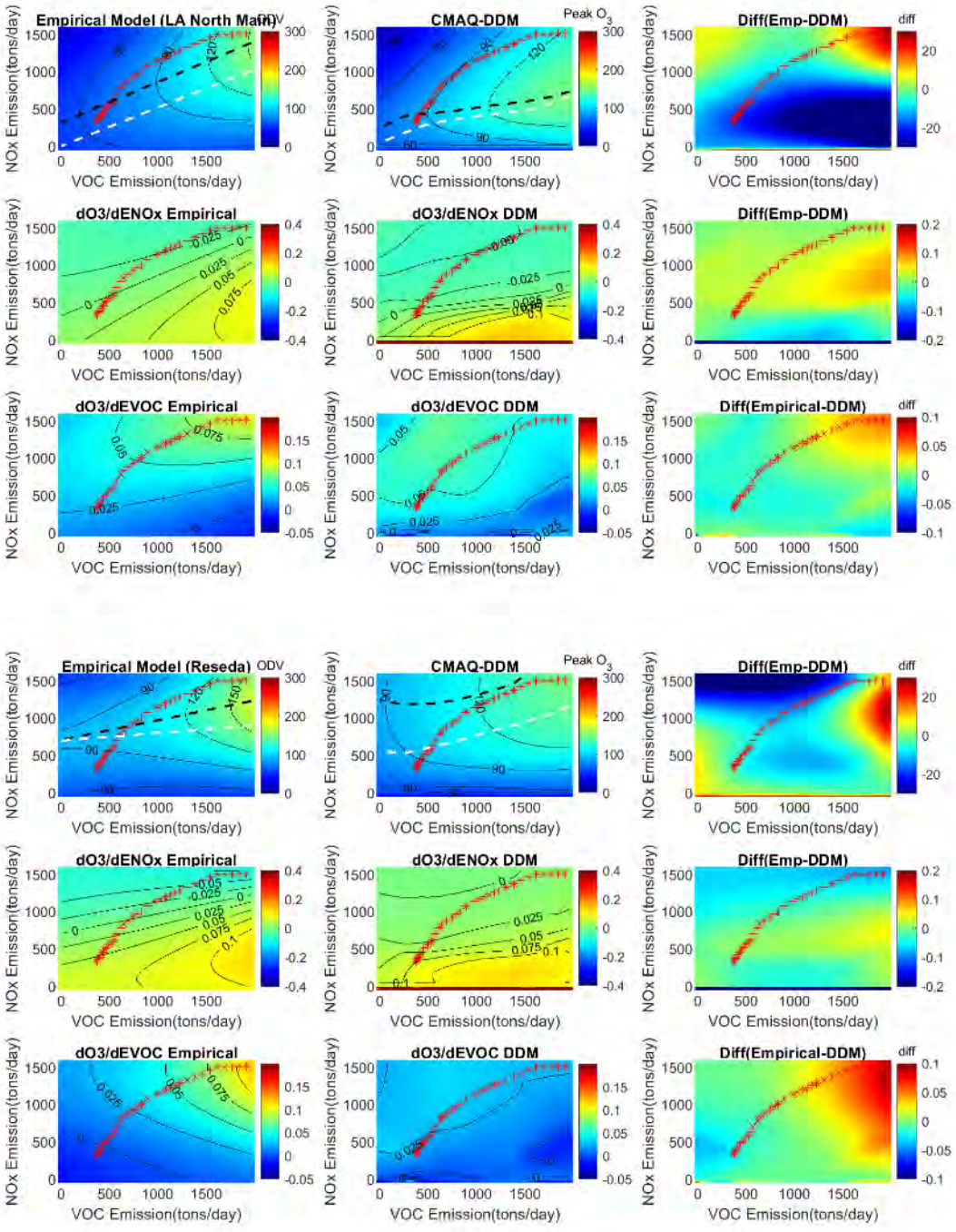
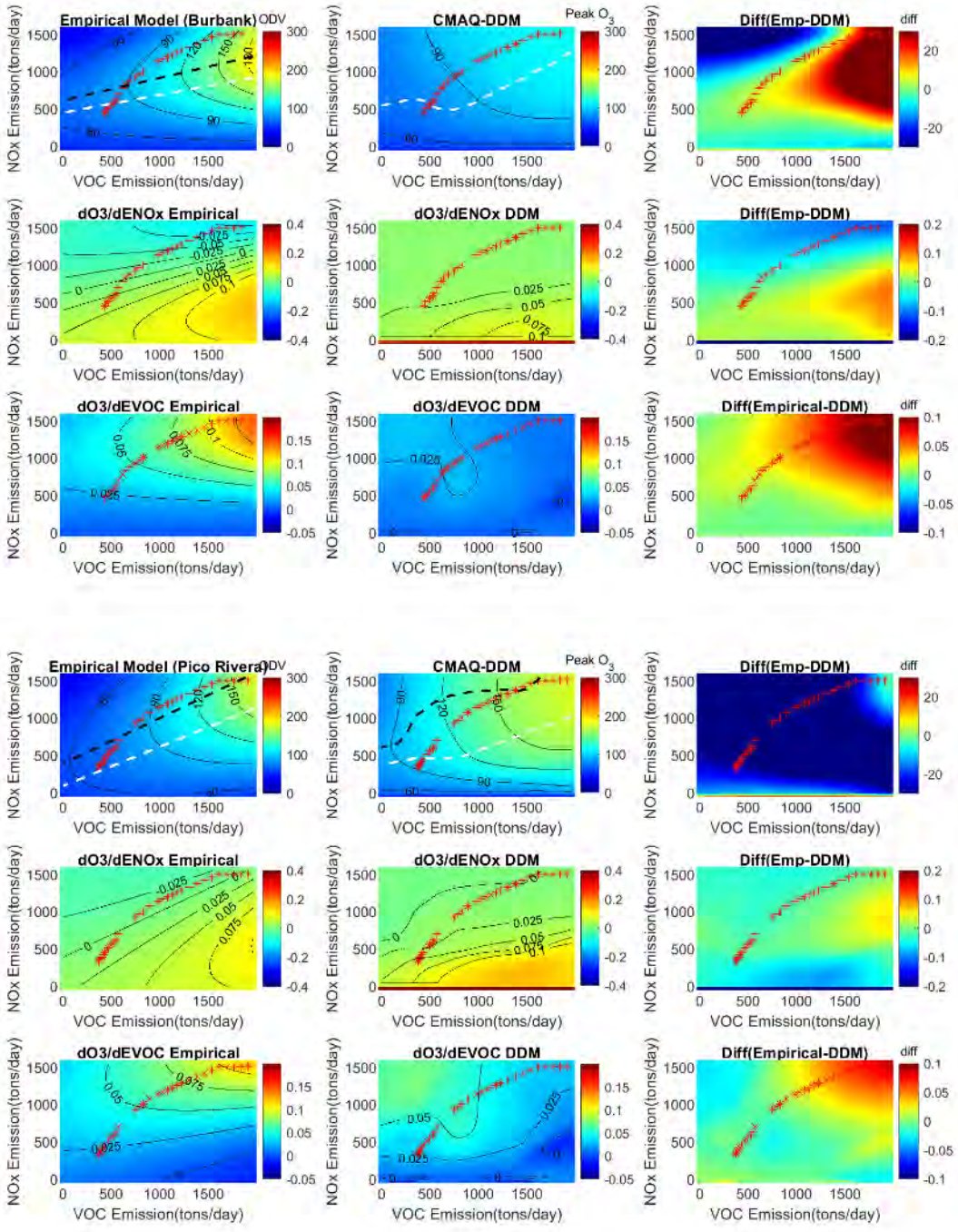


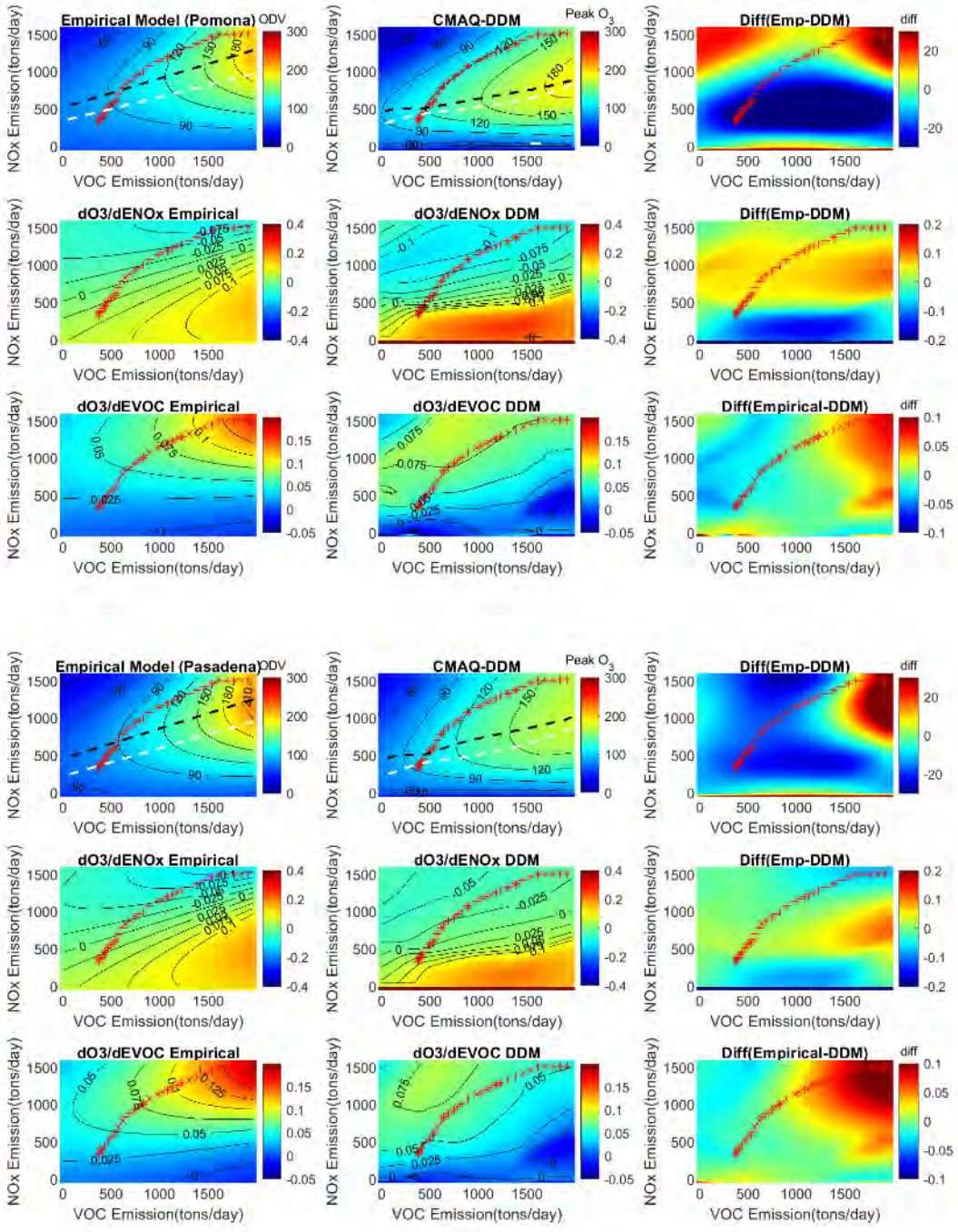
Figure J.1 The CMAQ-HDDM-based ozone-emissions concentrations and sensitivity isopleth (based on the SRIDW method) and the comparison with empirically derived isopleth. The first column shows the empirically derived isopleths. The second column shows the CMAQ-HDDM based isopleths. The third column shows the difference between those two. The first row shows the ozone concentration isopleths; the second row shows the ozone-to-NOx emissions sensitivity isopleths; and the third row shows the ozone-to-VOC emissions sensitivity isopleths. The black dash line indicates the zero-NOx-sensitivity line, and the white dash line indicates the equal-NOx-VOC sensitivity line. The site is Azusa. Results for other sites shown below in this section follow the same layout.

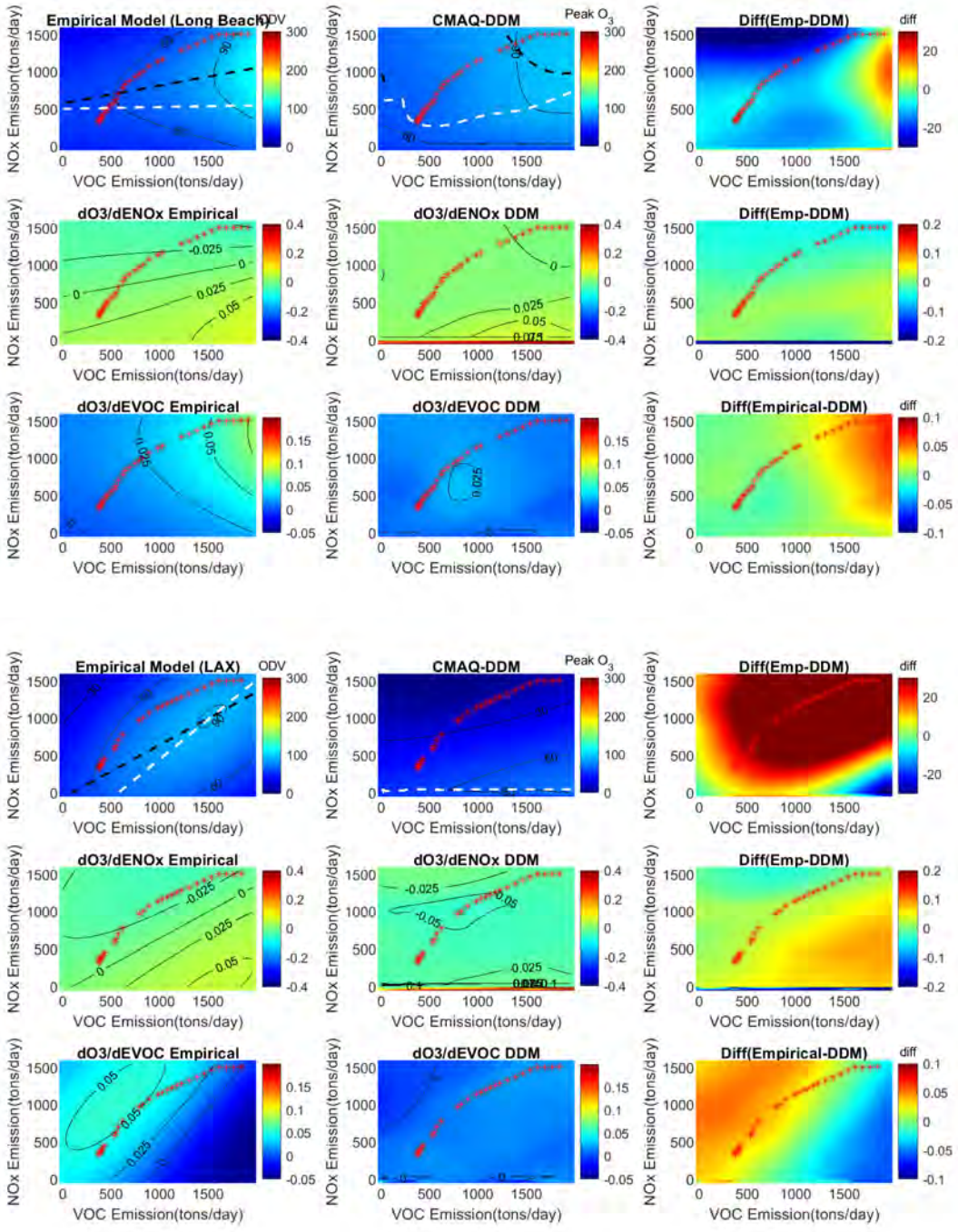

Empirical Model (Glendora)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)

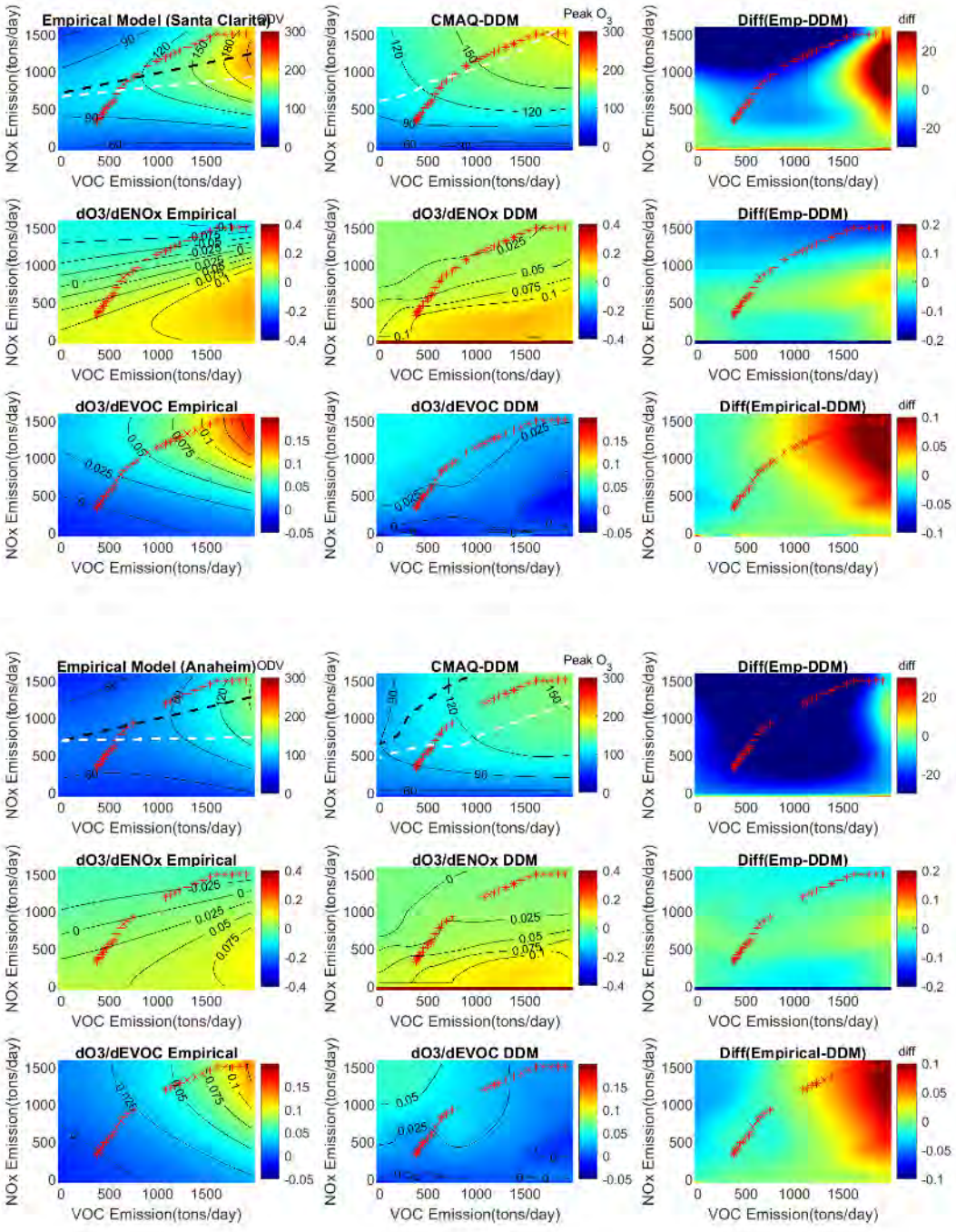

Empirical Model (West LA)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)

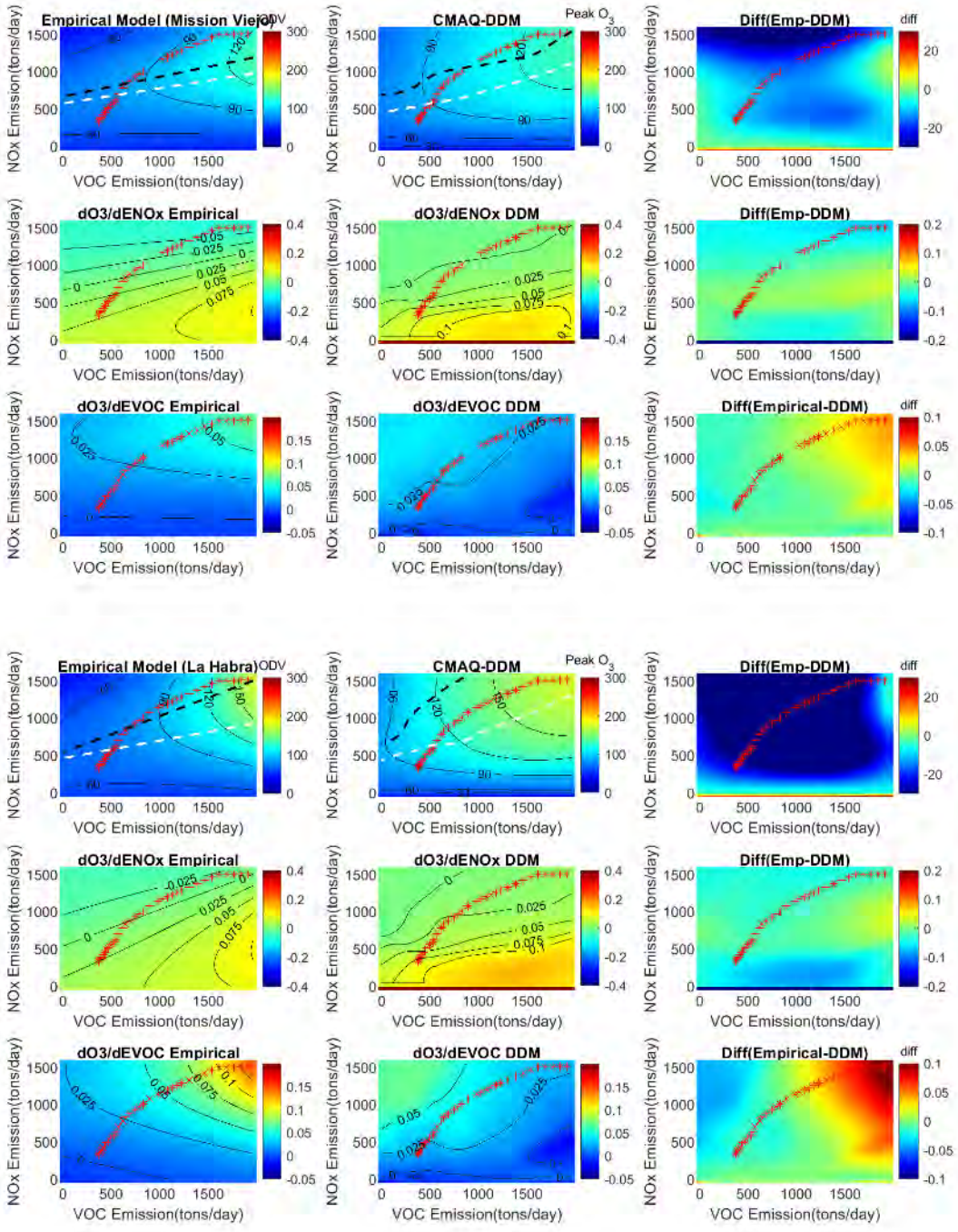

Empirical Model (LA North Main)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Reseda)
NOx Emission(tons/day)
VOC Emission(tons/day)

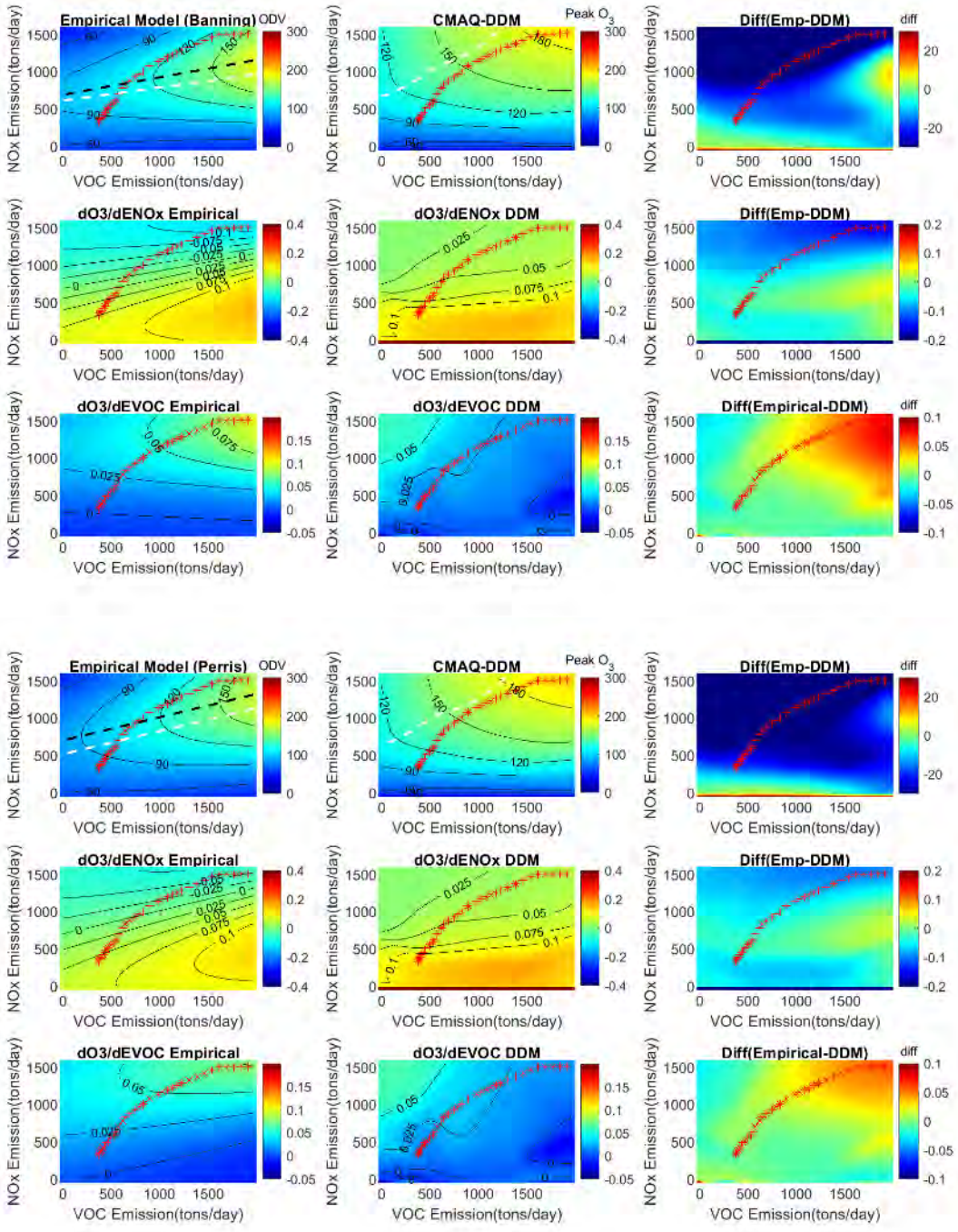

Empirical Model (Burbank)
CMAQ-DDM
Diff(Emp-DDM)
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Pico Rivera)
CMAQ-DDM
Diff(Emp-DDM)
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)
ODV
Peak O3
diff

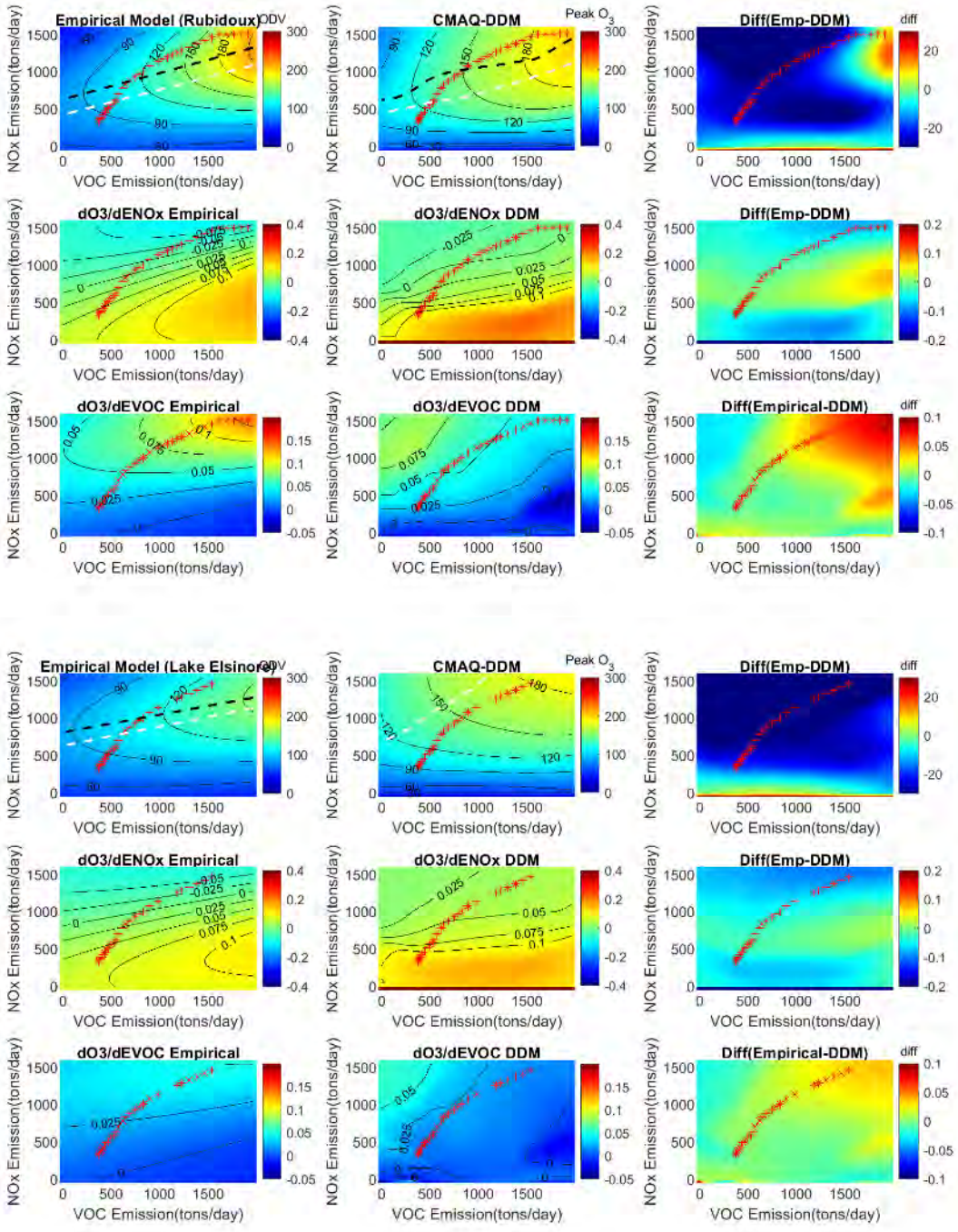

Empirical Model (Pomona) ODV
CMAQ-DDM Peak O3
Diff(Emp-DDM) diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Pasadena) ODV
CMAQ-DDM Peak O3
Diff(Emp-DDM) diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)

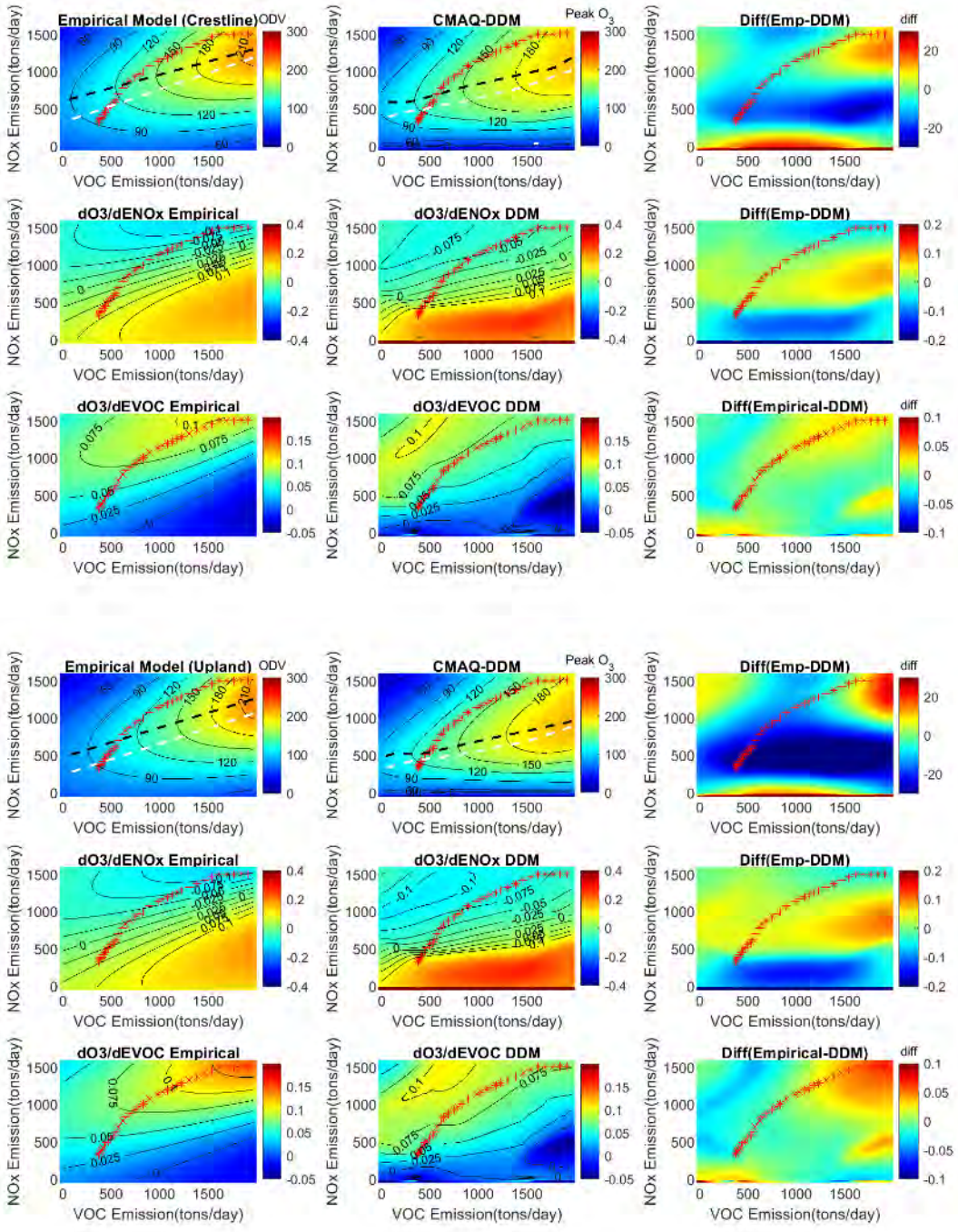

Empirical Model (Long Beach)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (LAX)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)

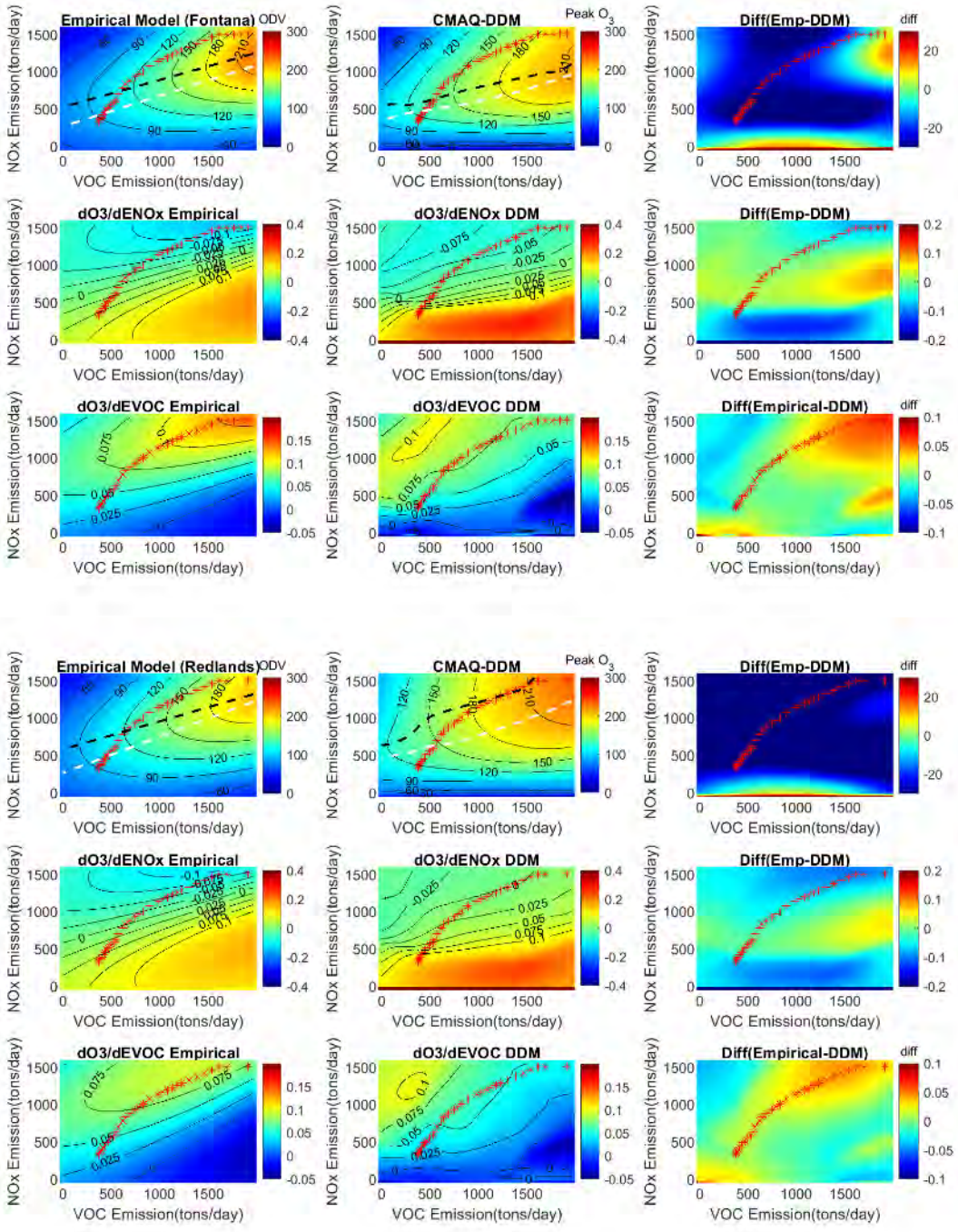

Empirical Model (Santa Clarita)
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Anaheim)
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)
ODV
diff

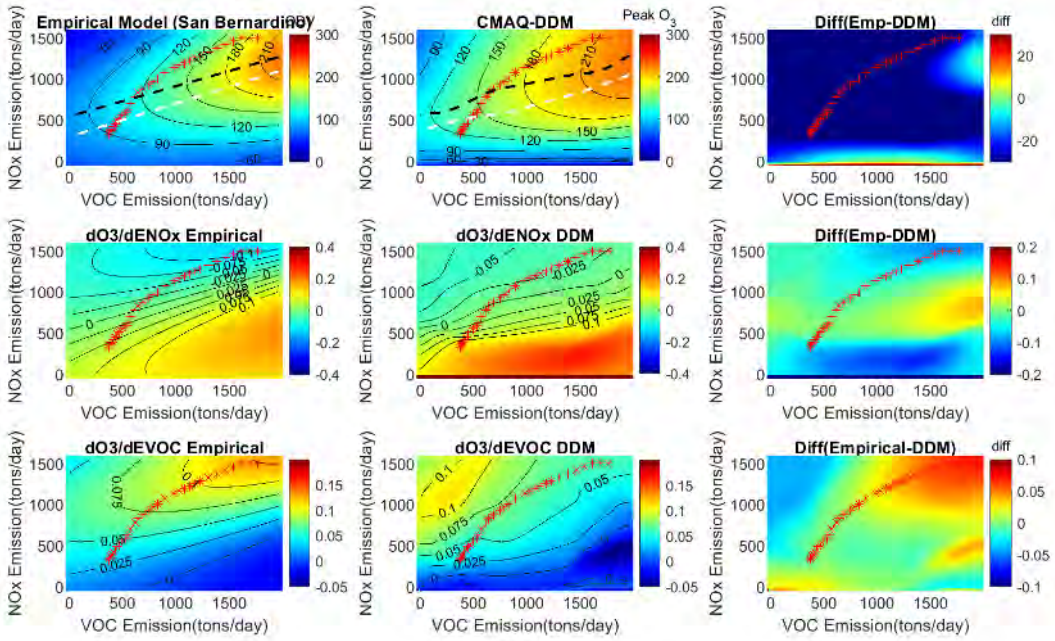

Empirical Model (Mission Viejo)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (La Habra)
NOx Emission(tons/day)
VOC Emission(tons/day)


Empirical Model (Banning)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Perris)
NOx Emission(tons/day)
VOC Emission(tons/day)


Empirical Model (Rubidoux)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Lake Elsinore)
NOx Emission(tons/day)
VOC Emission(tons/day)


Empirical Model (Crestline) ODV
CMAQ-DDM Peak O3
Diff(Emp-DDM) diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Upland) ODV
CMAQ-DDM Peak O3
Diff(Emp-DDM) diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
NOx Emission(tons/day)
VOC Emission(tons/day)


Empirical Model (Fontana)
ODV
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
Empirical Model (Redlands)
NOx Emission(tons/day)
VOC Emission(tons/day)


Empirical Model (San Bernardino)
CMAQ-DDM
Peak O3
Diff(Emp-DDM)
diff
dO3/dENOx Empirical
dO3/dENOx DDM
Diff(Emp-DDM)
dO3/dEVOC Empirical
dO3/dEVOC DDM
Diff(Empirical-DDM)
diff
NOx Emission(tons/day)
VOC Emission(tons/day)

Appendix K: Ozone Concentration and Sensitivity Isopleth of Empirical Model, CMAQ-HDDM Model (based on quadratic fitting method), and the Difference Between Each Other

Developing ozone isopleths provides a direct method for comparing sensitivities between the empirical and CTM-based models. Qualitative approaches for comparing the two include visual inspection of ozone isopleths generated by the quadratic-fitting method and similarly comparing sensitivity isopleths. We show the developed ozone and sensitivity isopleth based on empirical model and CMAQ-HDDM model and the difference between methods for each individual monitoring site.

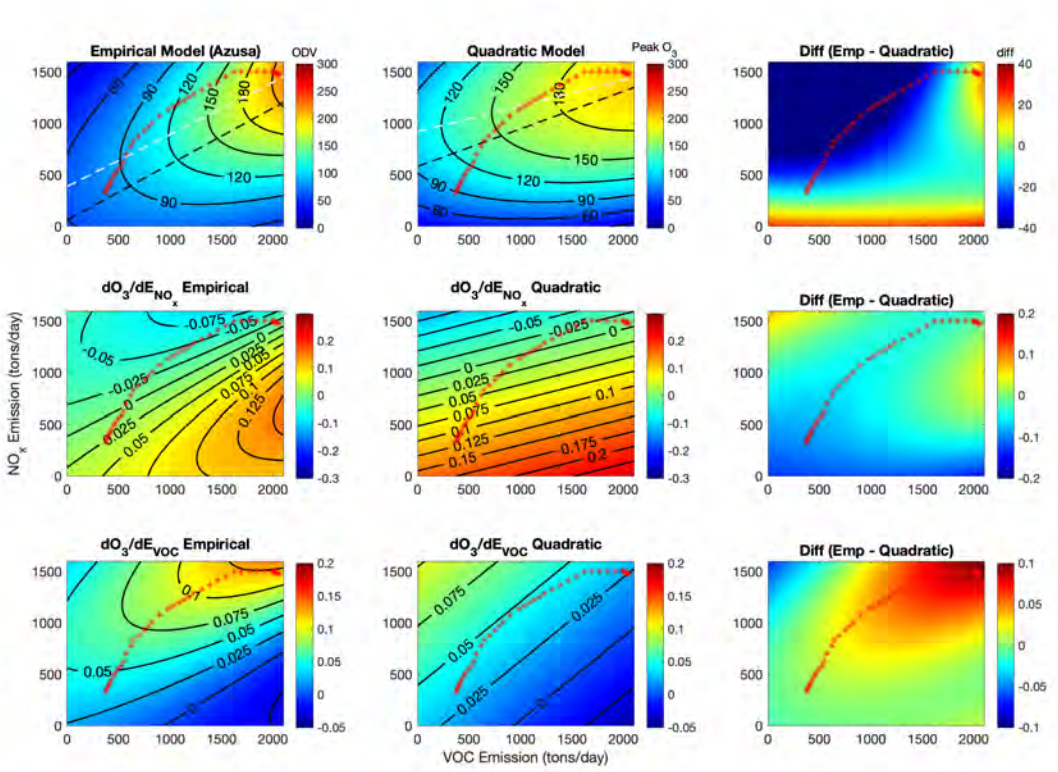
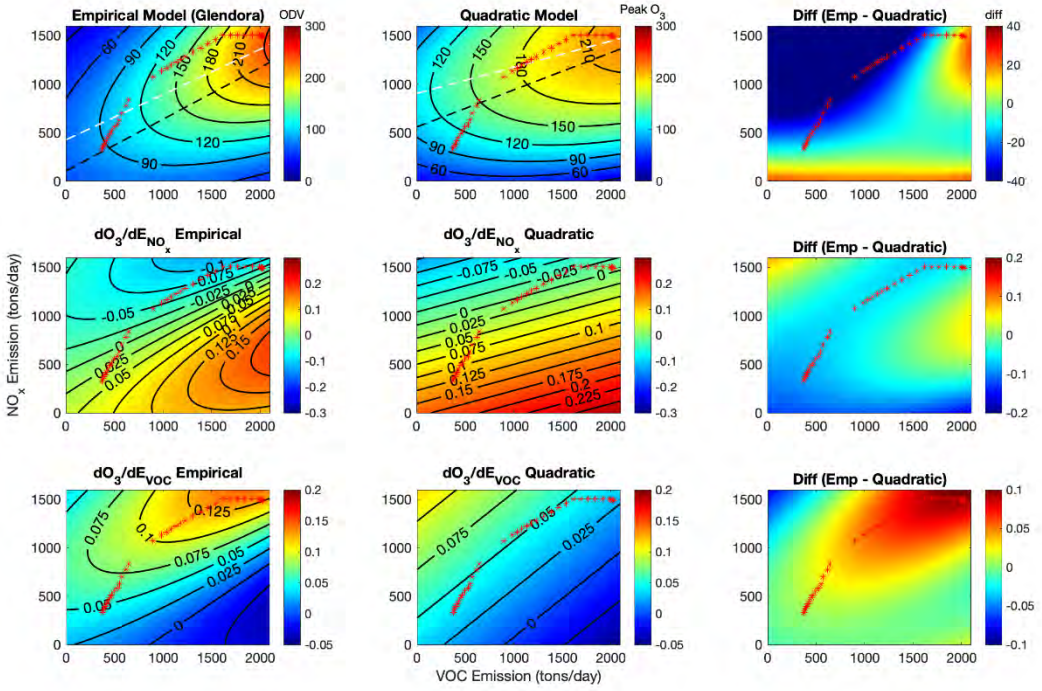
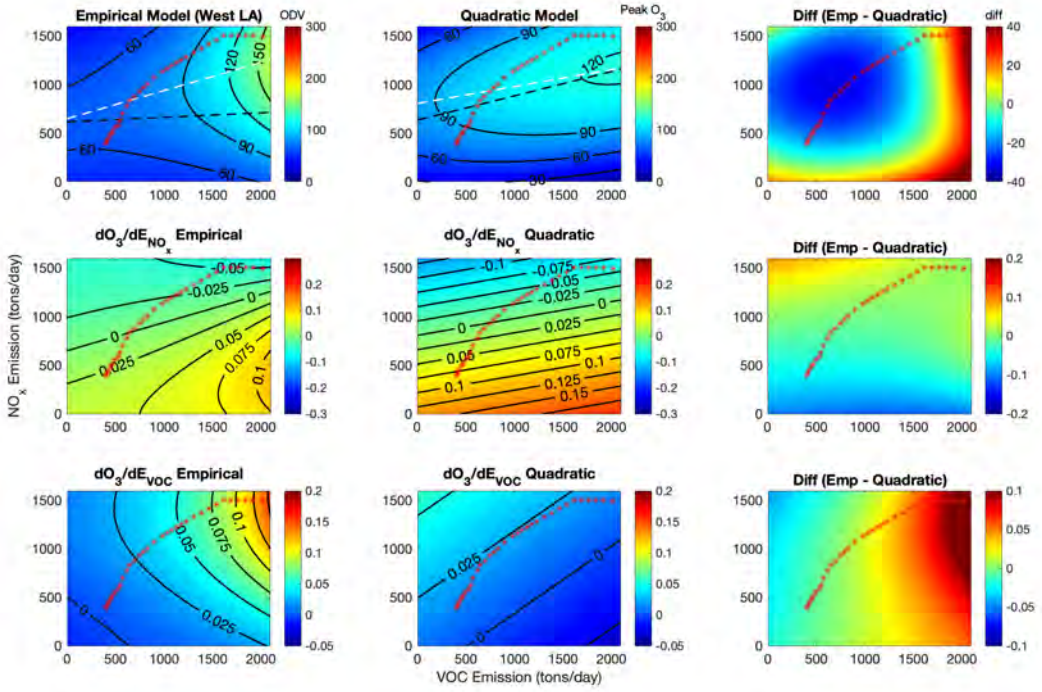
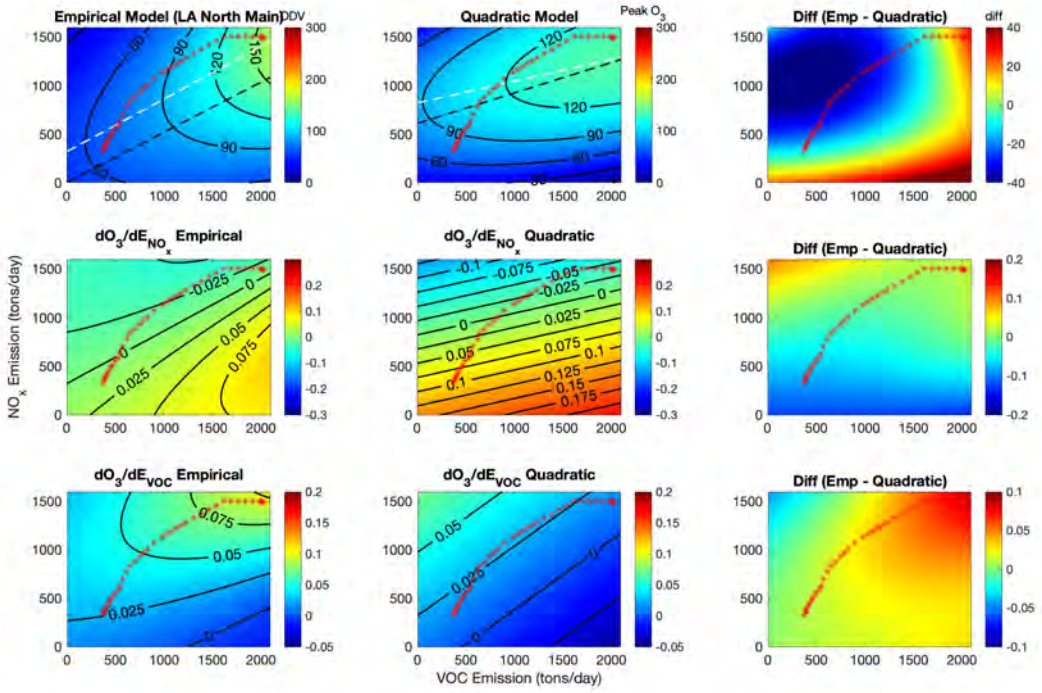
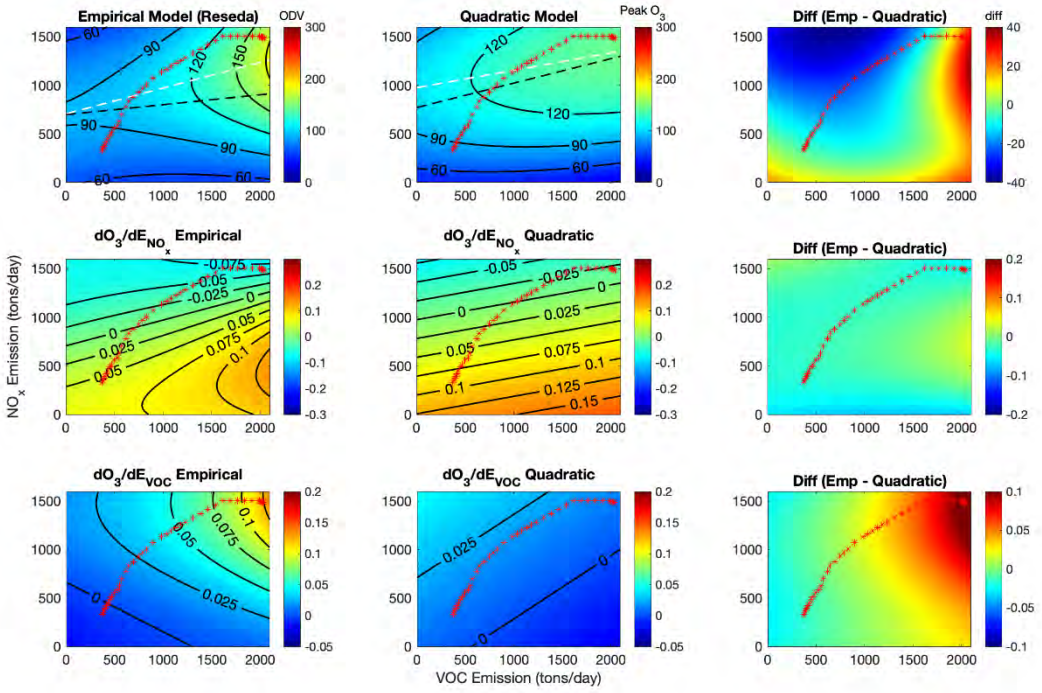


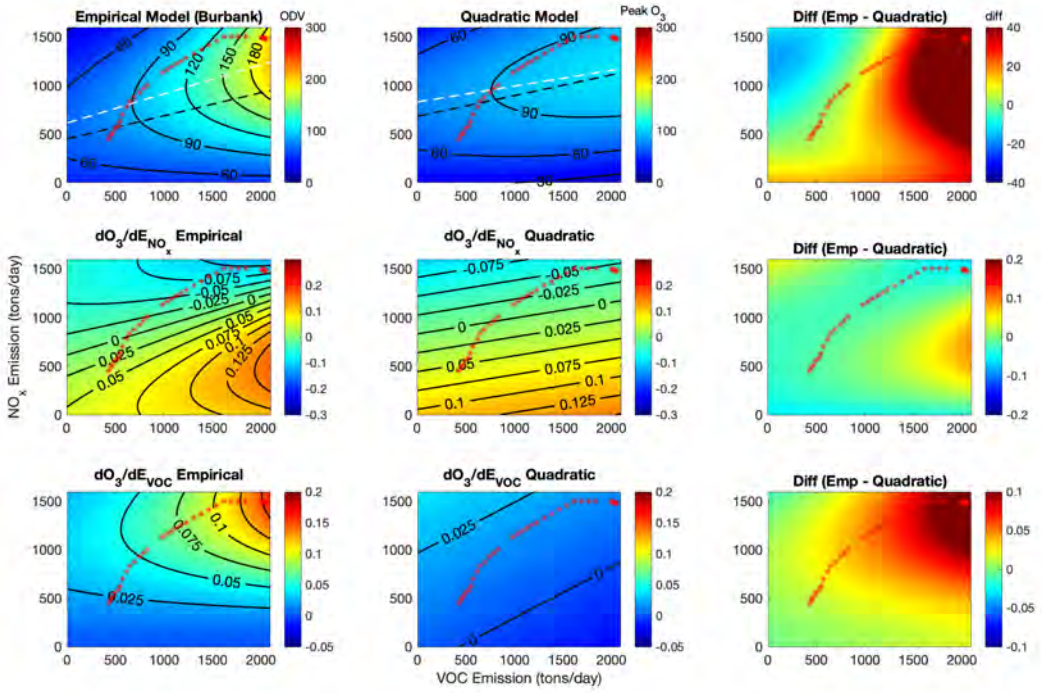
Figure K.1 The CMAQ-HDDM-based ozone-emissions concentrations and sensitivity isopleth (based on the quadratic-fitting method) and the comparison with empirically derived isopleth for Azusa. The first column shows the empirically derived isopleths. The second column shows the CMAQ-HDDM based isopleths. The third column shows the difference between those two. The first row shows the ozone concentration isopleths; the second row shows the ozone-to-NOx emissions sensitivity isopleths; and the third row shows the ozone-to-VOC emissions sensitivity isopleths. The white dash line indicates the zero-NOx-sensitivity line, and the black dash line indicates the equal-NOx-VOC sensitivity line. Results for other sites shown below in this section follow the same layout.

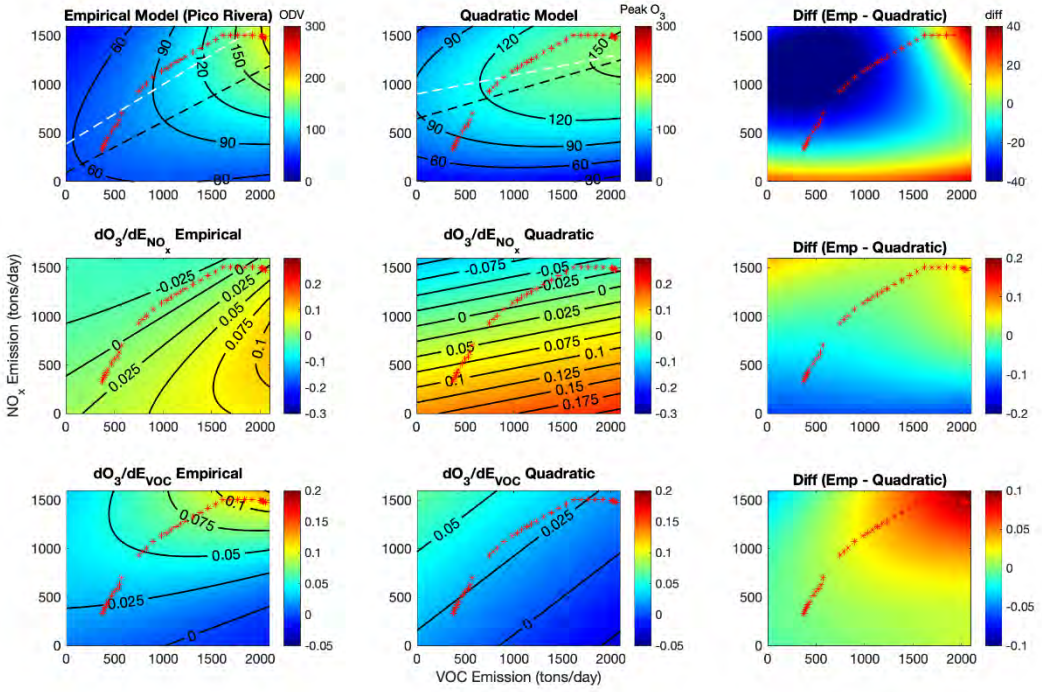

Empirical Model (Glendora)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

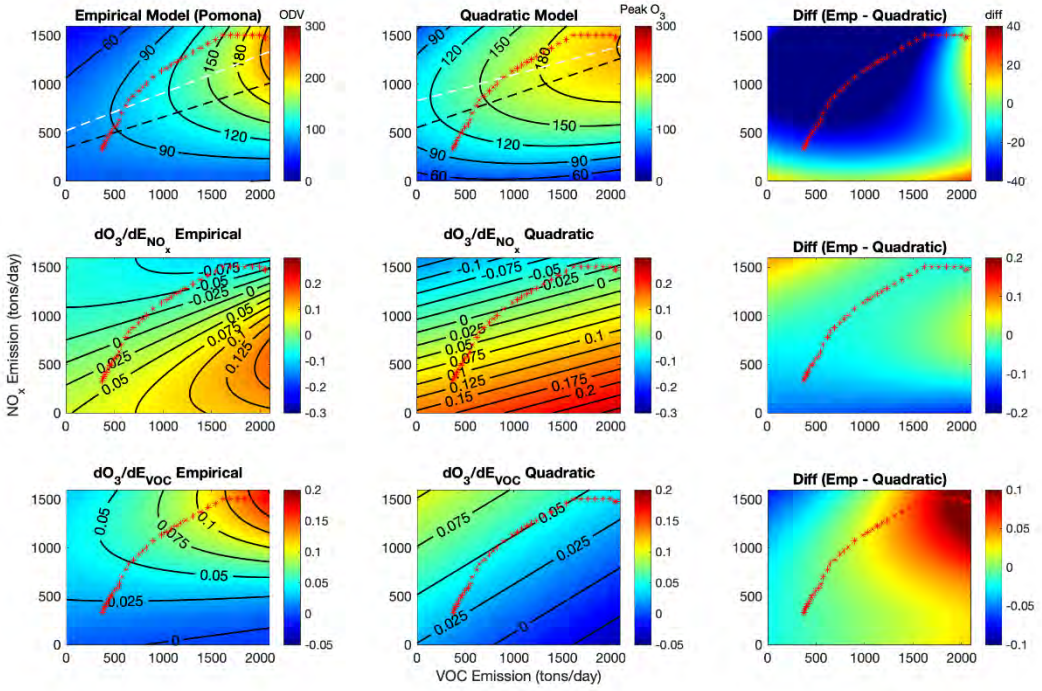

Empirical Model (West LA)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

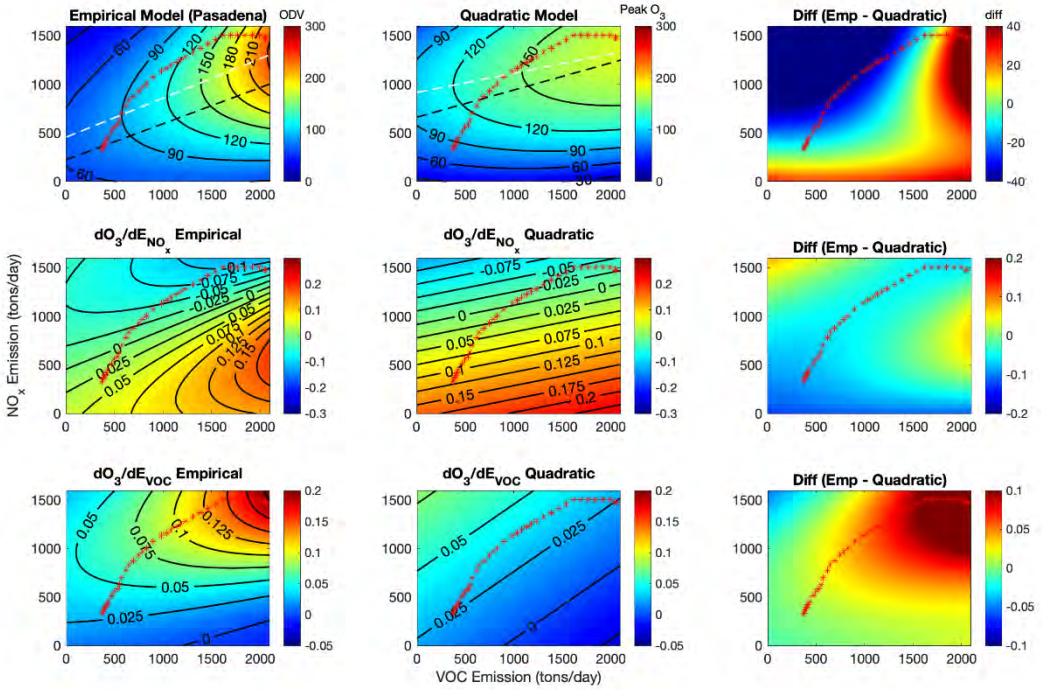

Empirical Model (LA North Main)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

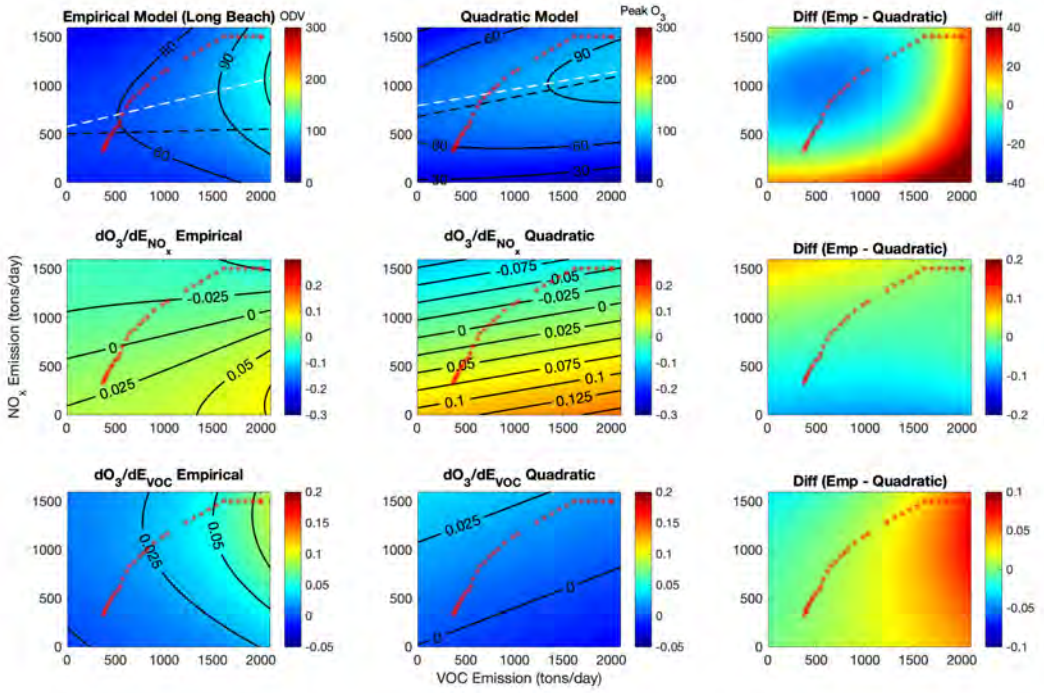

Empirical Model (Reseda)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

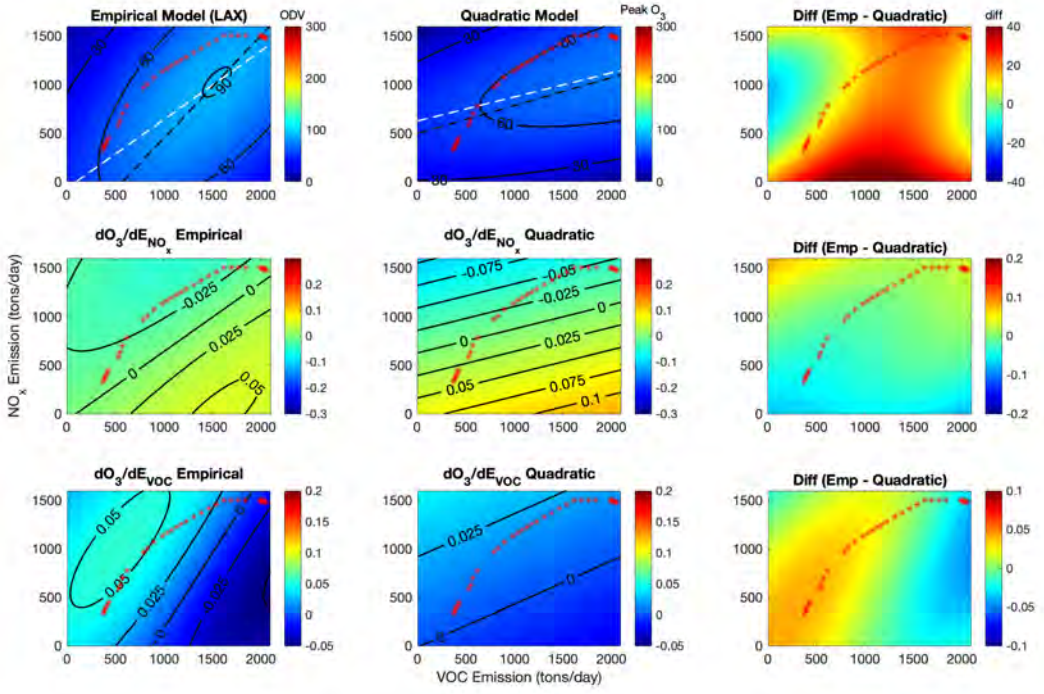

Empirical Model (Burbank)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

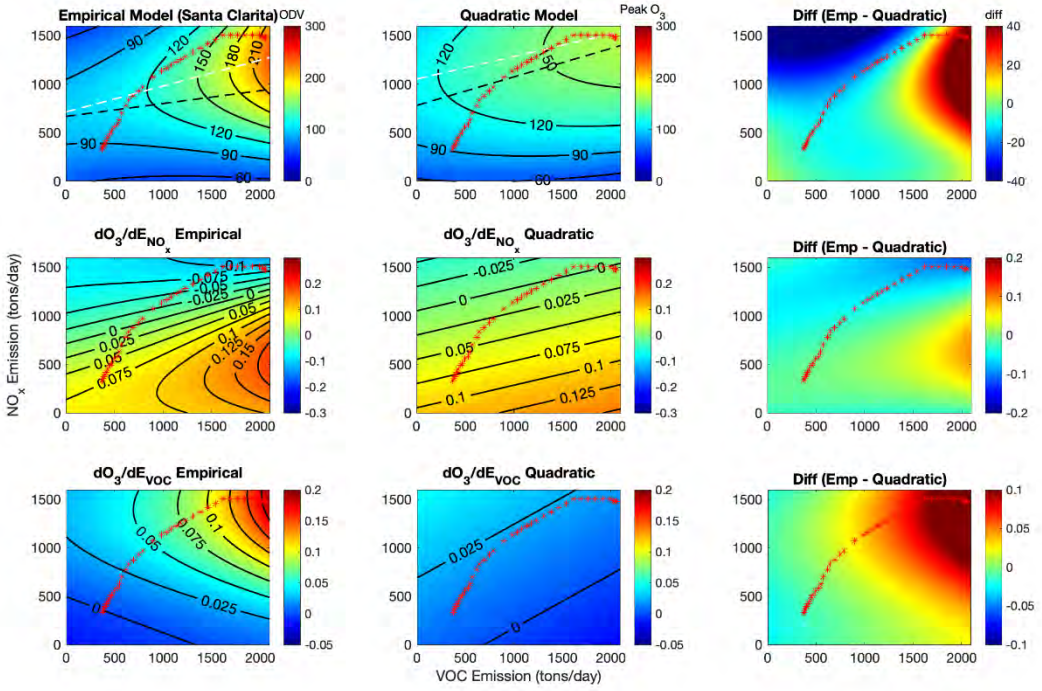

Empirical Model (Pico Rivera)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

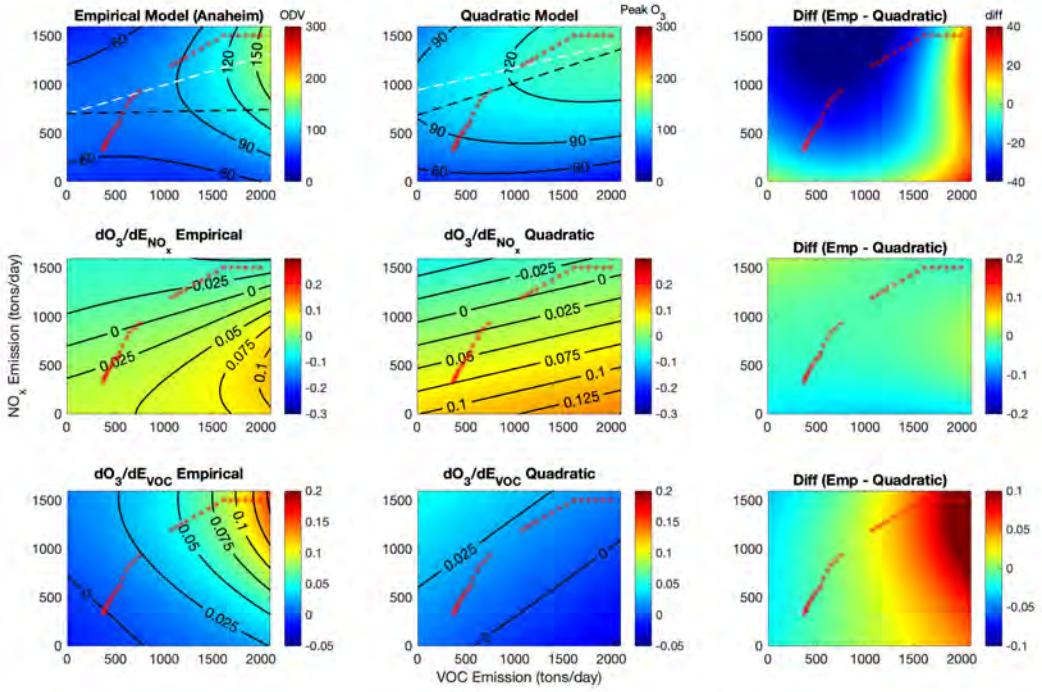

Empirical Model (Pomona)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

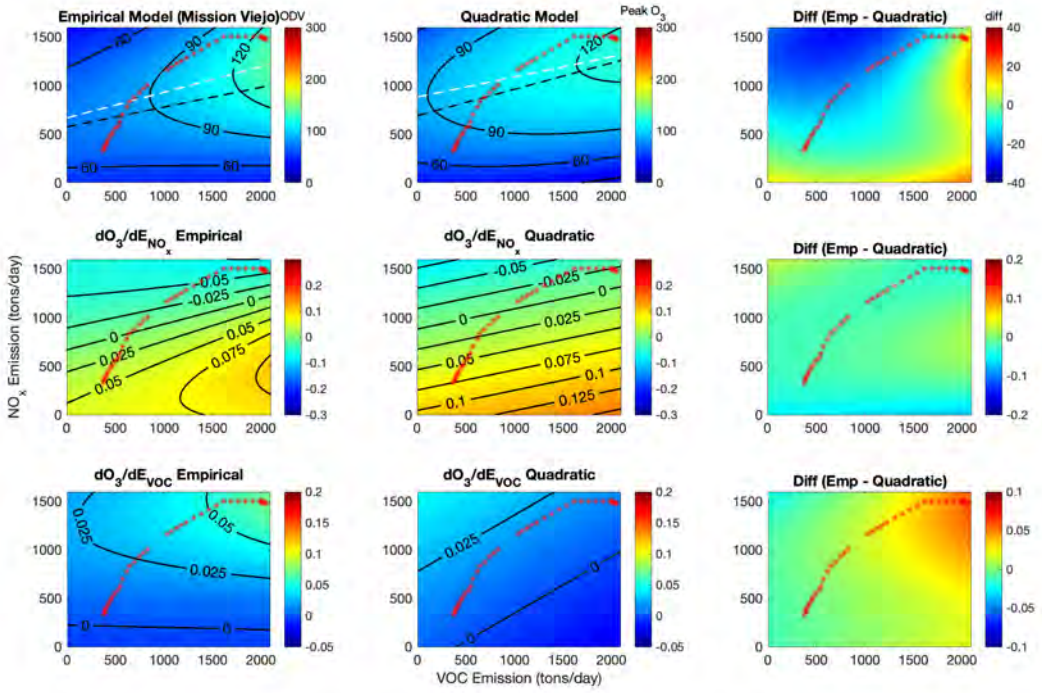

Empirical Model (Pasadena)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

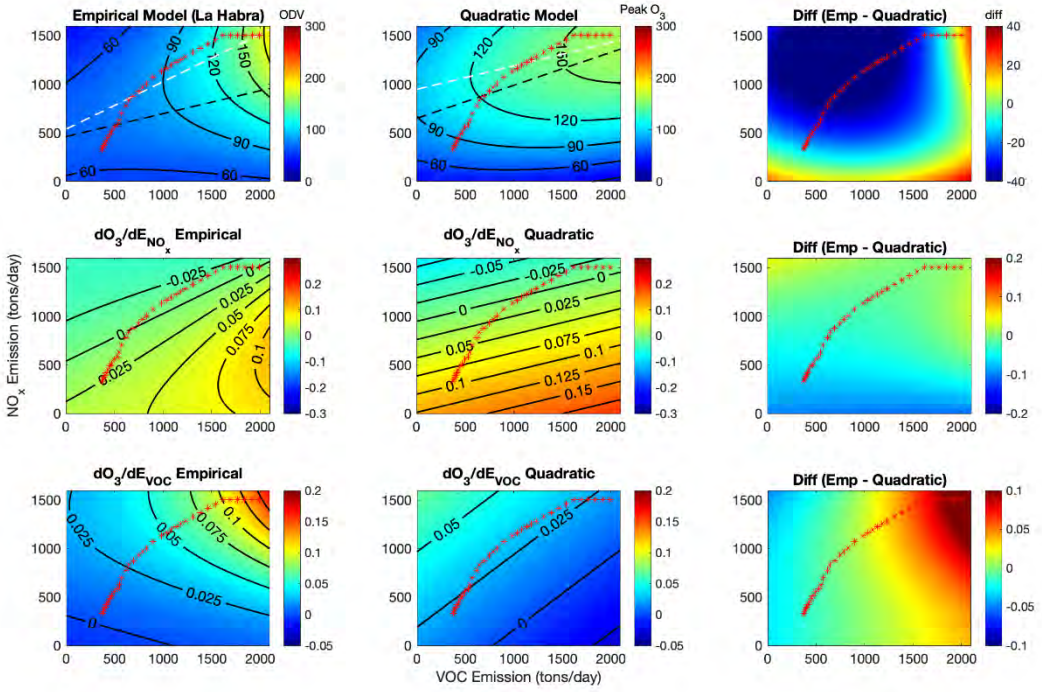

Empirical Model (Long Beach)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

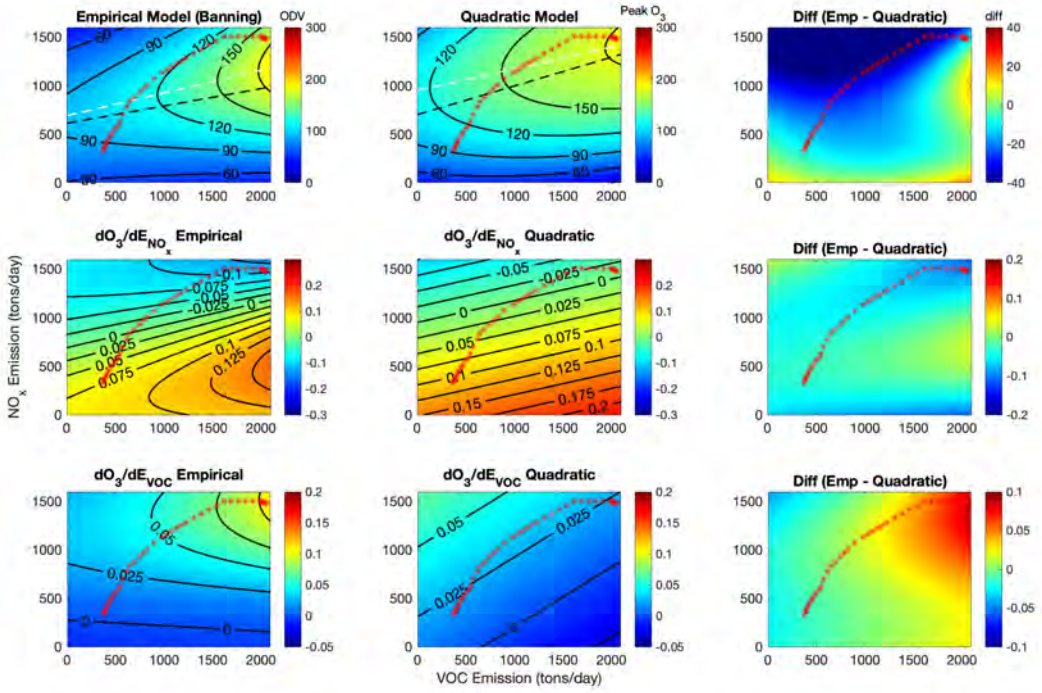

Empirical Model (LAX)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

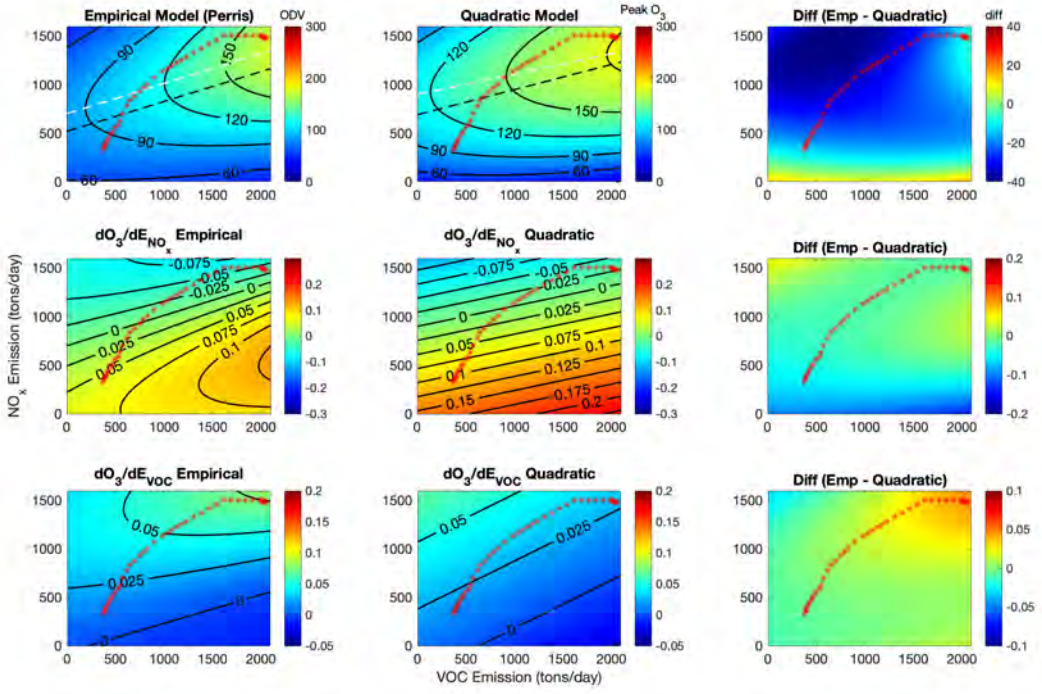

Empirical Model (Santa Clarita)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

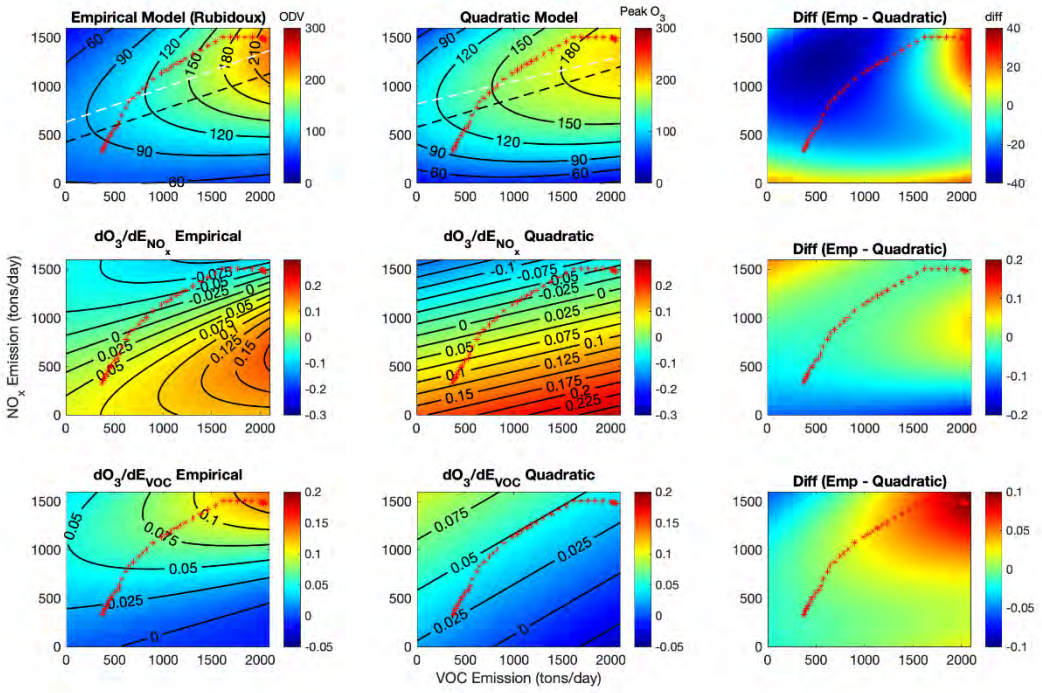

Empirical Model (Anaheim)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

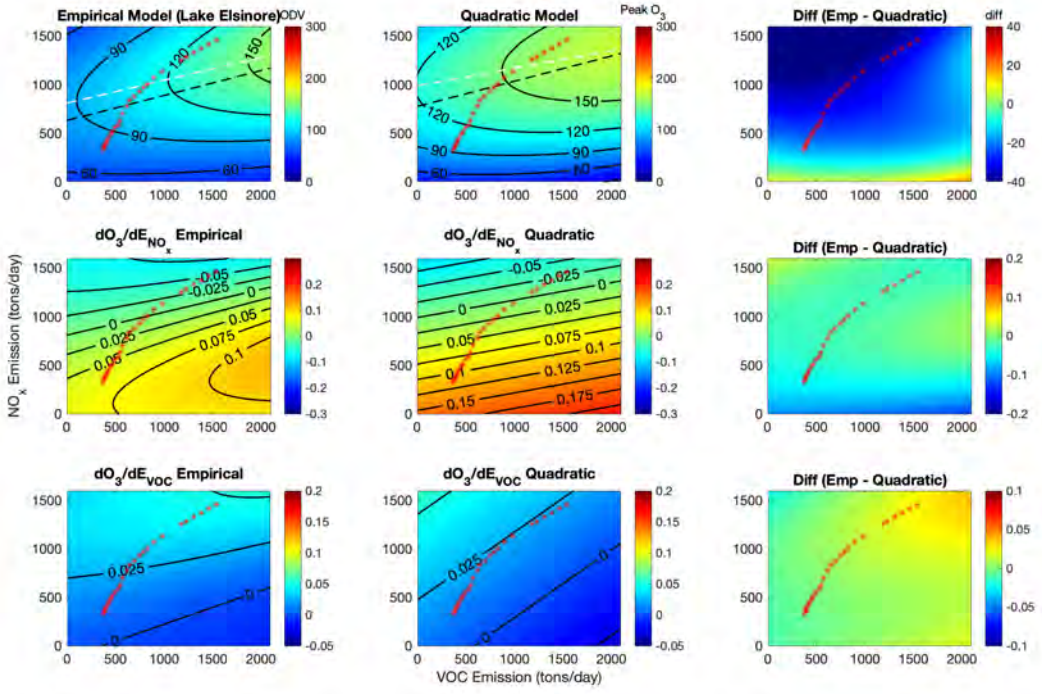

Empirical Model (Mission Viejo)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

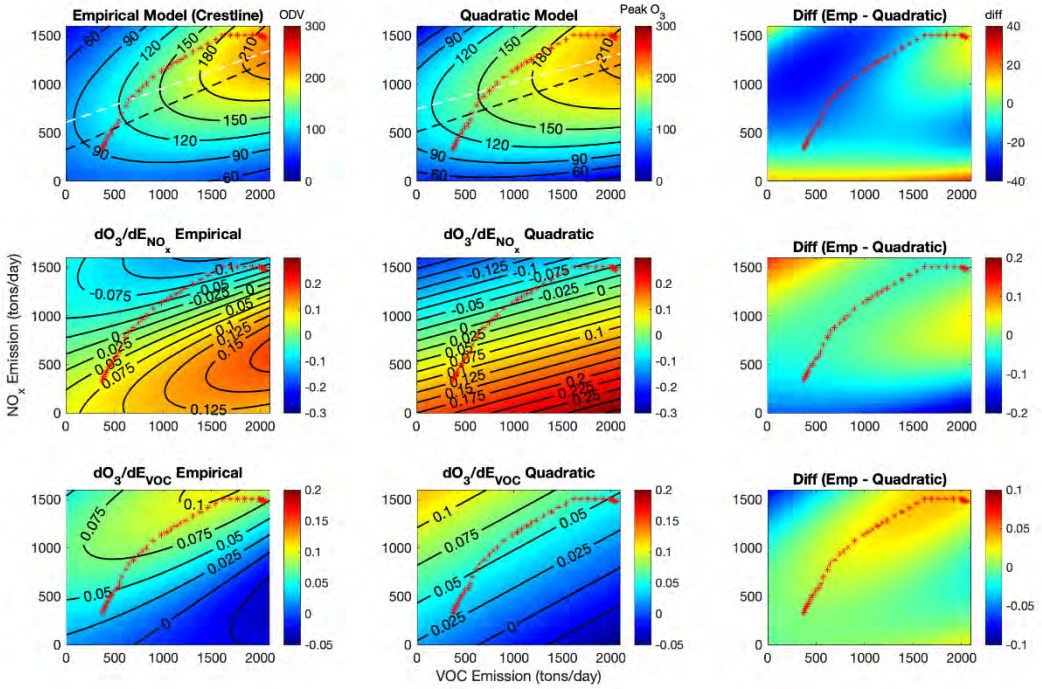

Empirical Model (La Habra)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

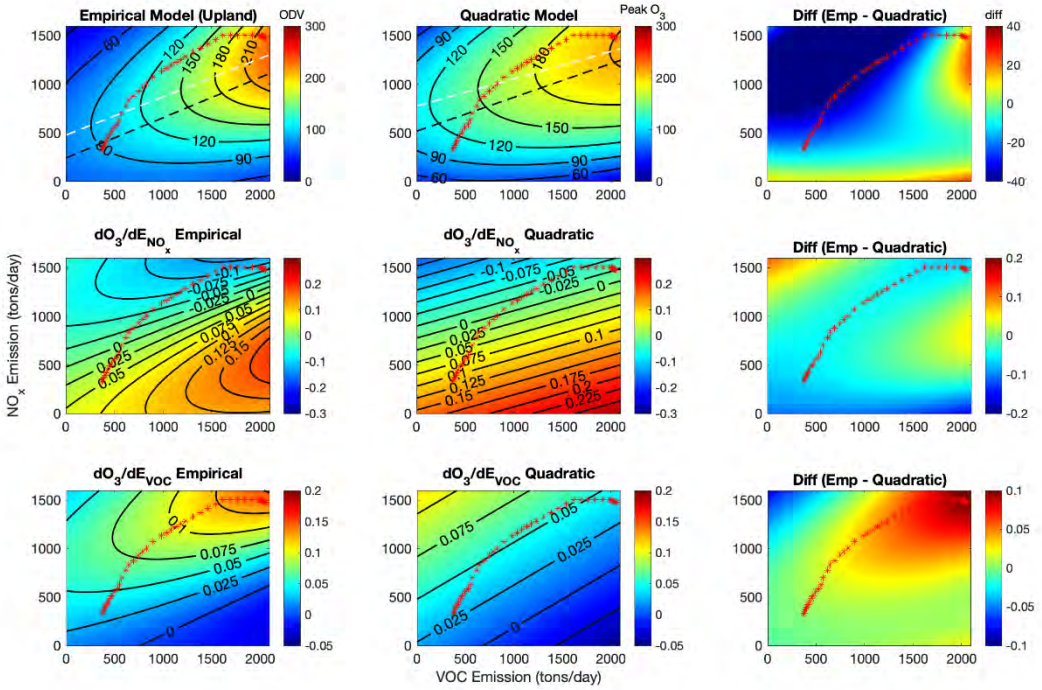

Empirical Model (Banning)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

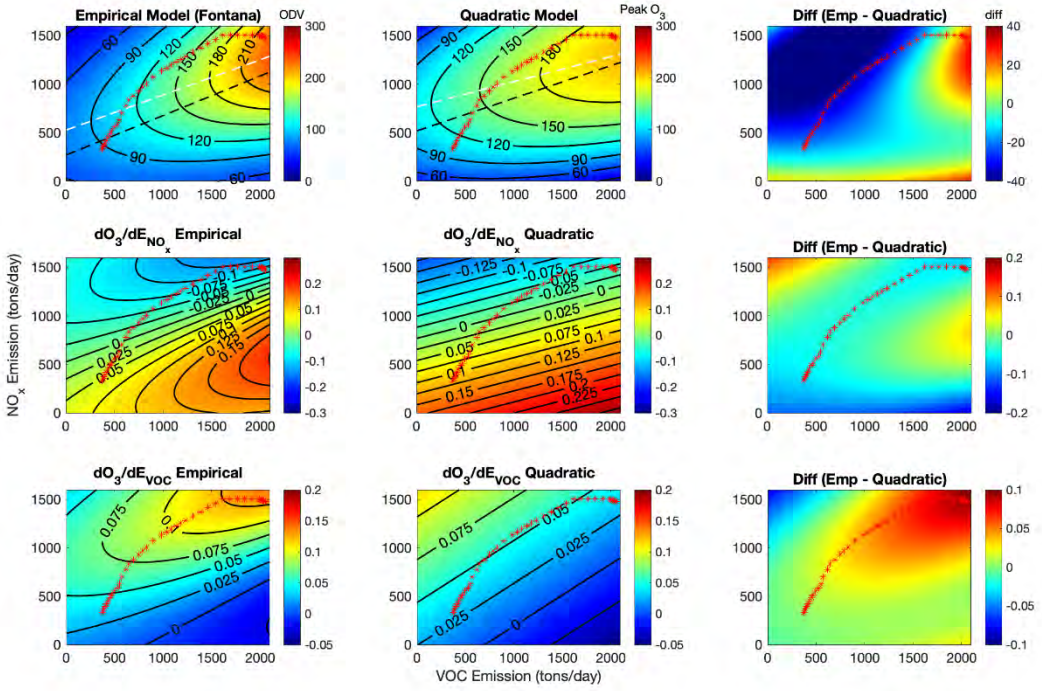

Empirical Model (Perris)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

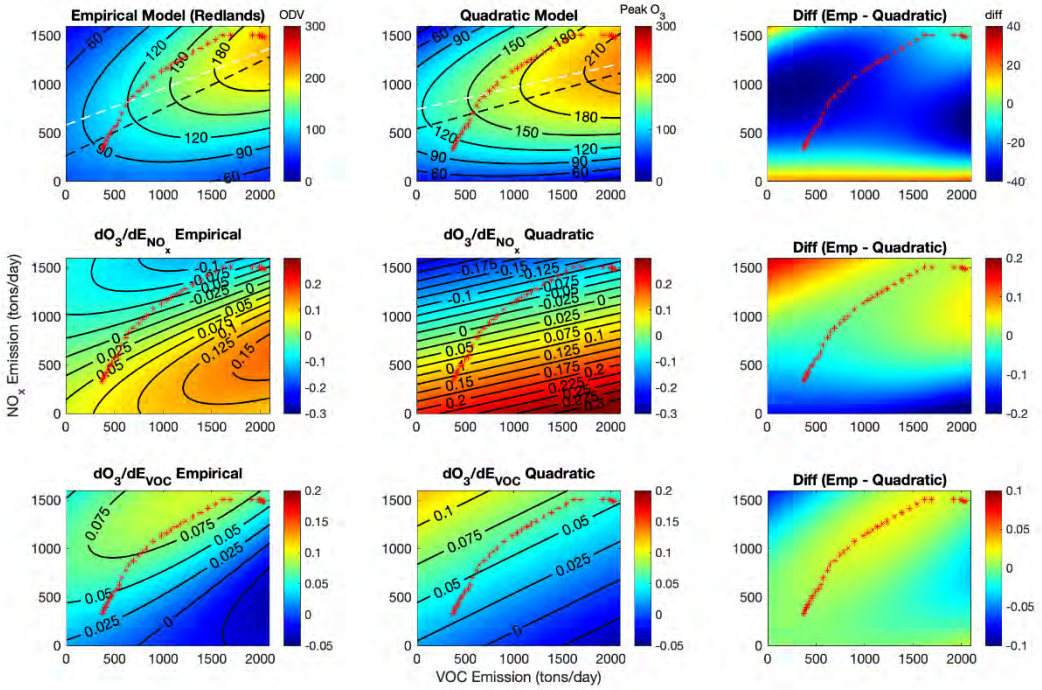

Empirical Model (Rubidoux)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)

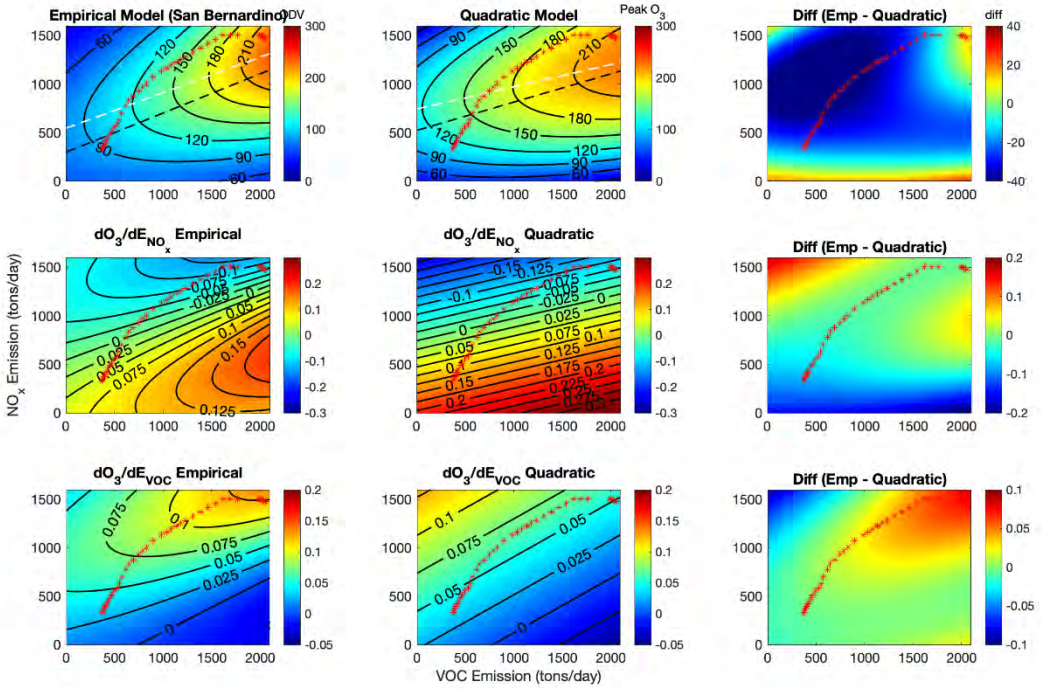

Empirical Model (Lake Elsinore)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
VOC Emission (tons/day)


Empirical Model (Crestline)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Empirical Model (Upland)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Empirical Model (Fontana)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Empirical Model (Redlands)
ODV
Quadratic Model
Peak O3
Diff (Emp - Quadratic)
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)


Empirical Model (San Bernardino)
Quadratic Model
Diff (Emp - Quadratic)
Peak O3
diff
dO3/dENOx Empirical
dO3/dENOx Quadratic
Diff (Emp - Quadratic)
dO3/dEVOC Empirical
dO3/dEVOC Quadratic
Diff (Emp - Quadratic)
NOx Emission (tons/day)
VOC Emission (tons/day)

Appendix L: Comparison of Ozone Concentrations and NOx and VOC Emissions Sensitivities between the CMAQ-HDDM Square-root Inverse Distance Weighted (SRIDW) -based Isopleths and Empirically Based Isopleths over Time for Historical Emissions Levels

A further evaluation of the differences between CMAQ-derived isopleths and the empirically derived isopleths can be made by comparing the estimated historical trends (along emissions trajectories) of ozone concentrations and ozone-to-emissions sensitivities. Using the isopleth, we were able to produce the trajectory for both ozone concentrations and sensitivities, which can be a good representation of how well the CTM captures the historical trends of the ozone response to emissions changes. We show the comparison between square-root inverse distance weighted-based estimation and empirically based estimation of ozone and sensitivities for each individual monitoring site.

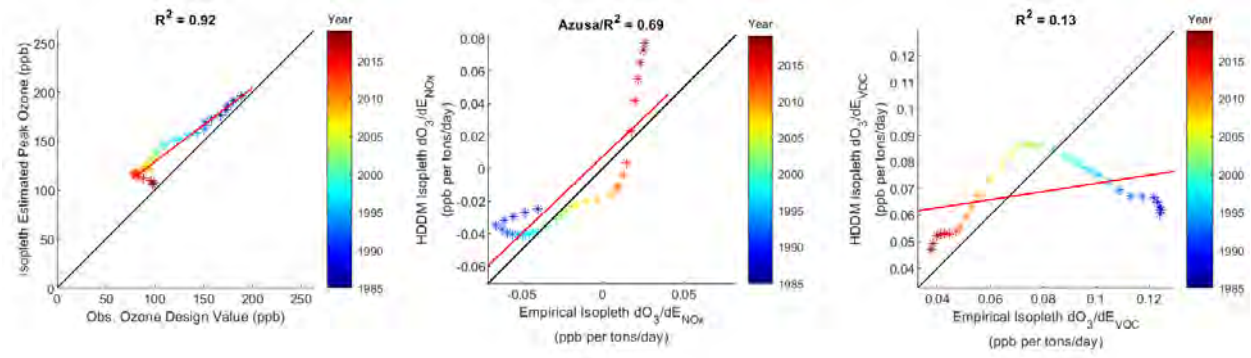
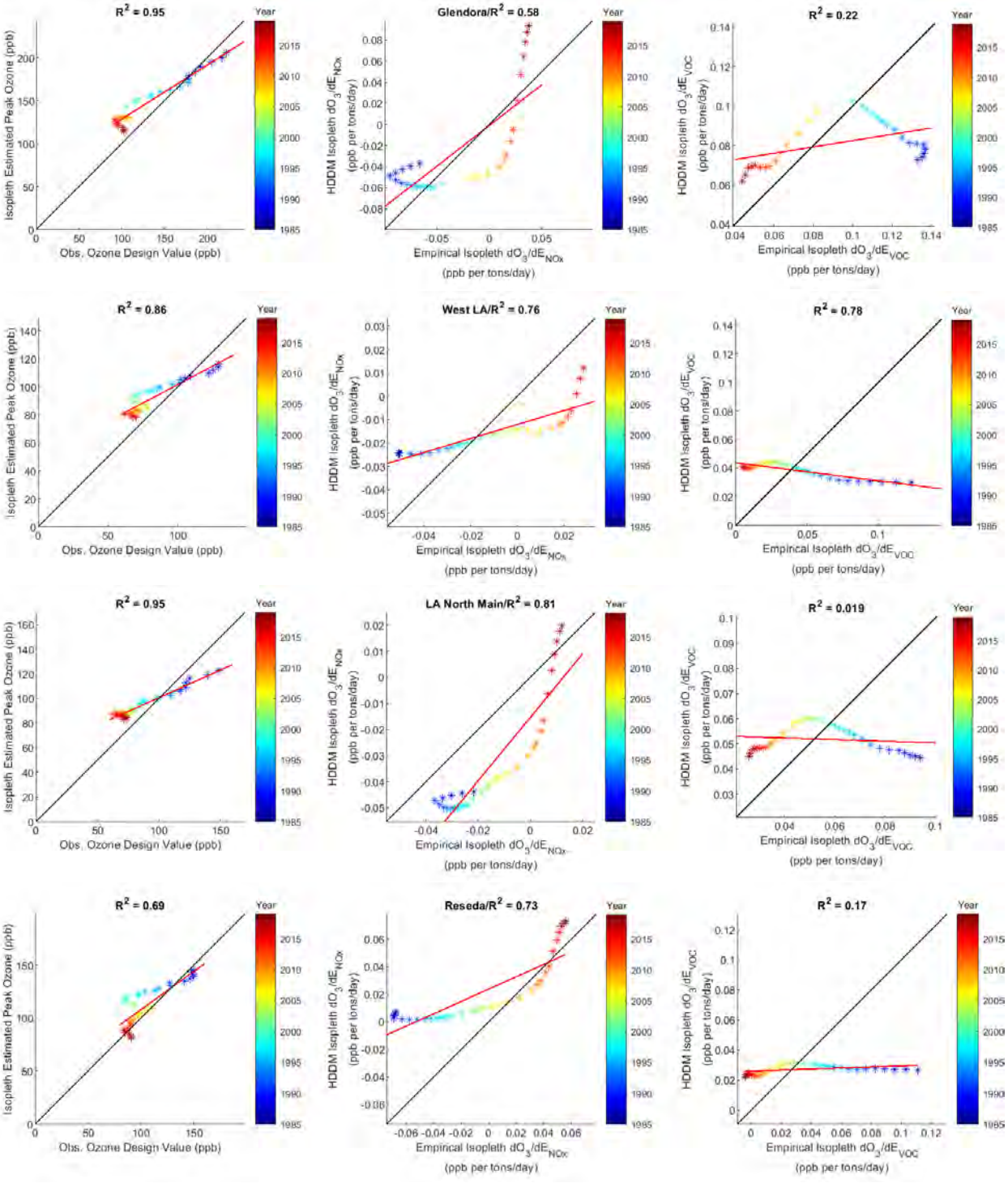
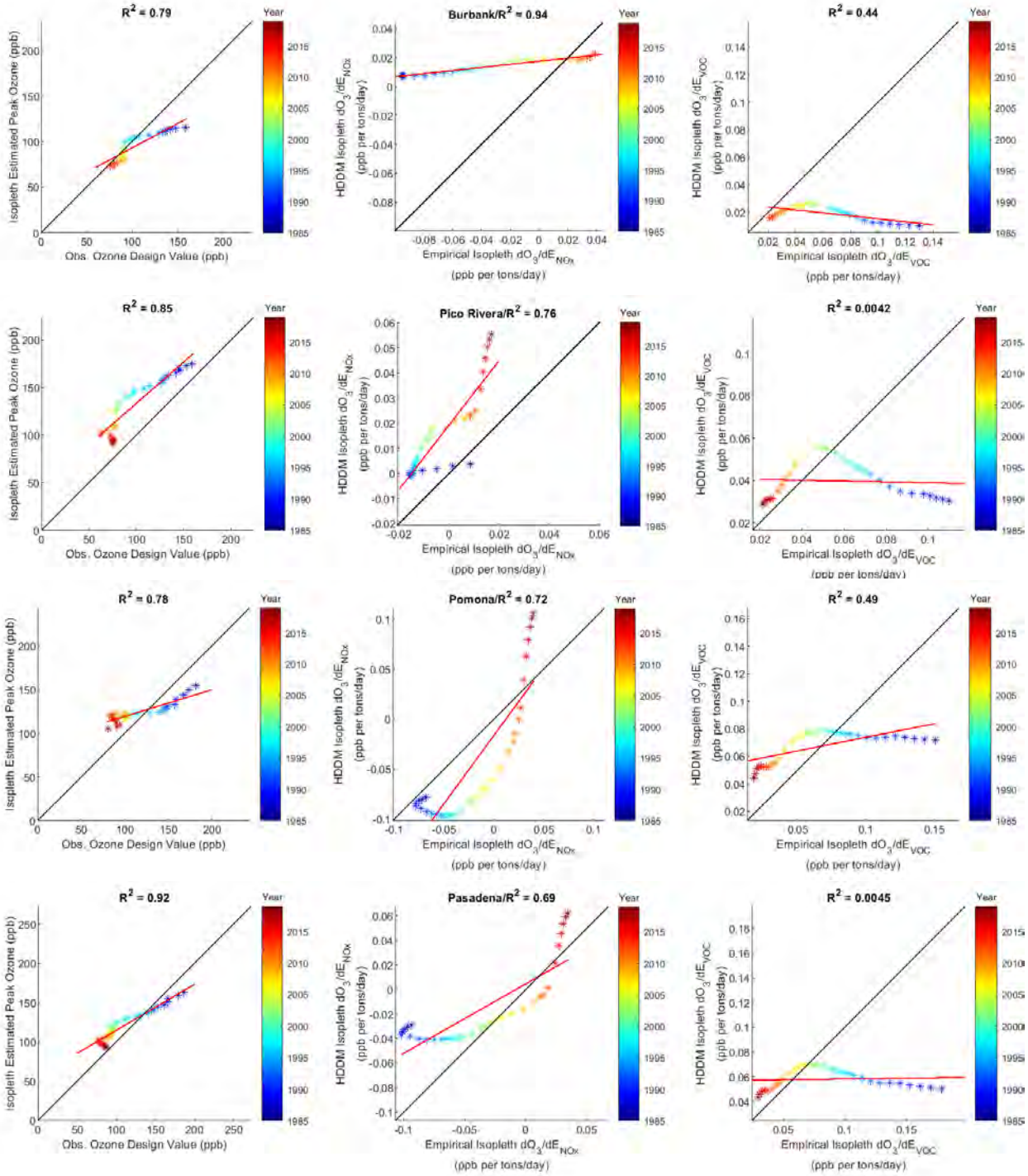
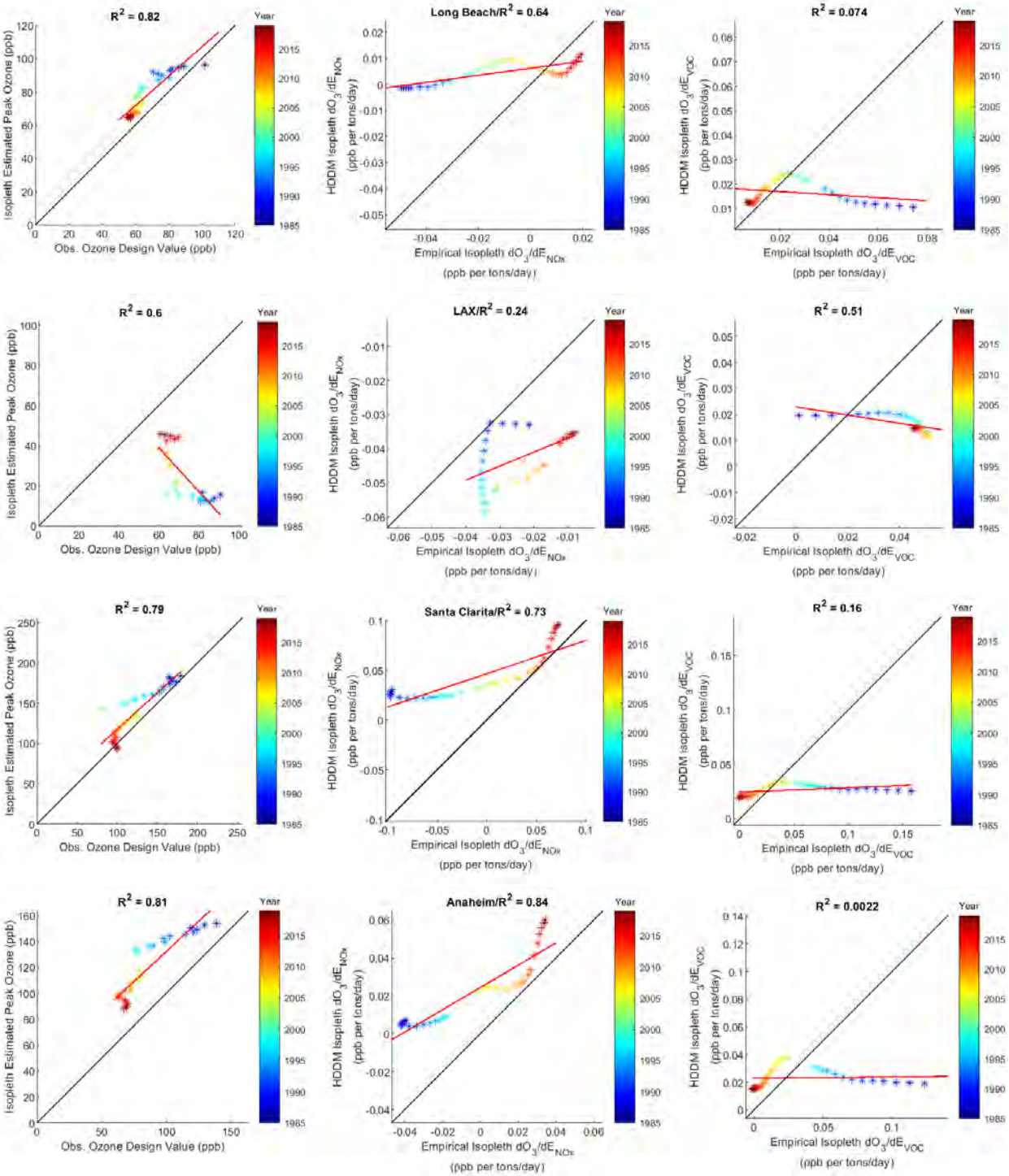
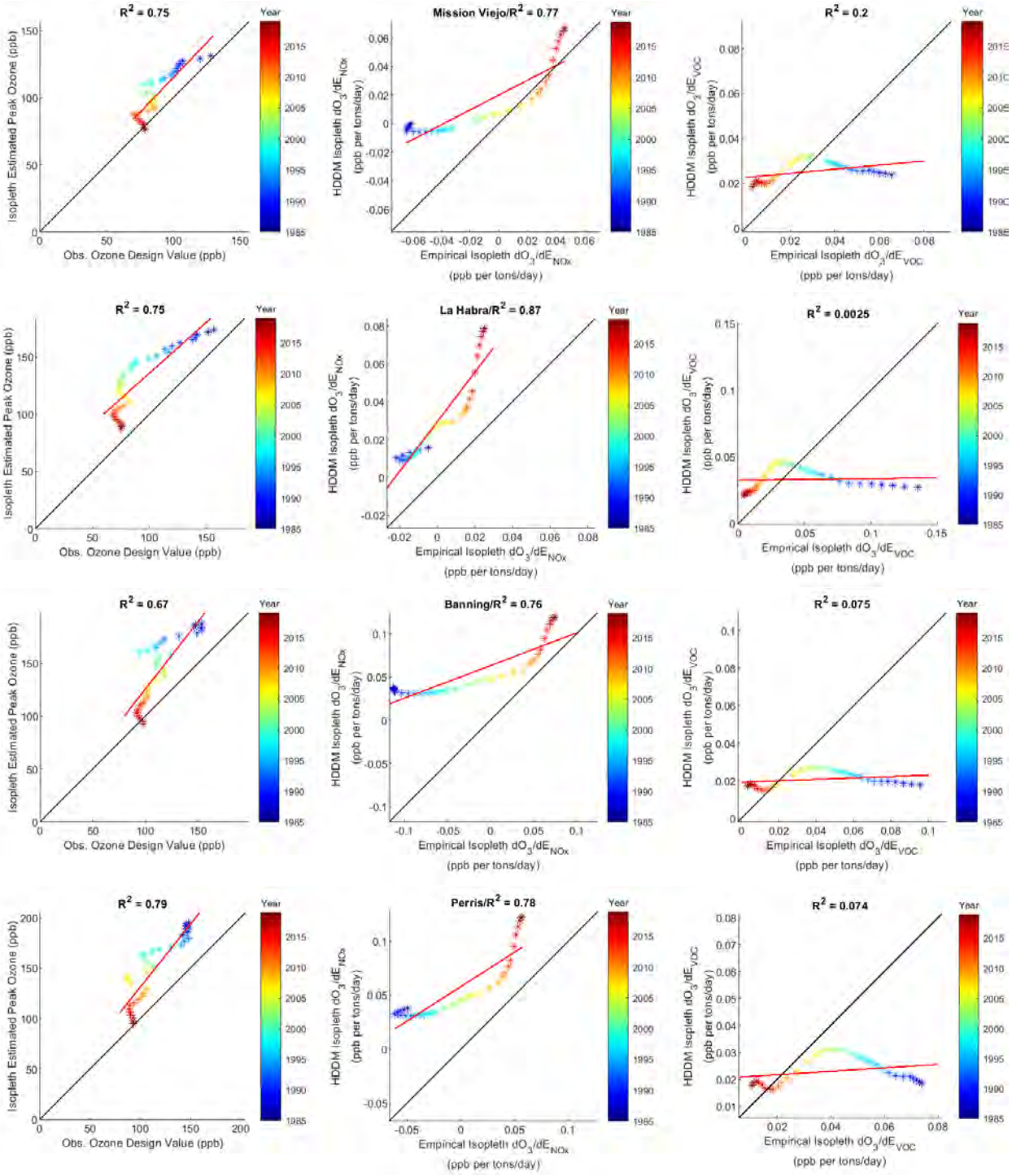


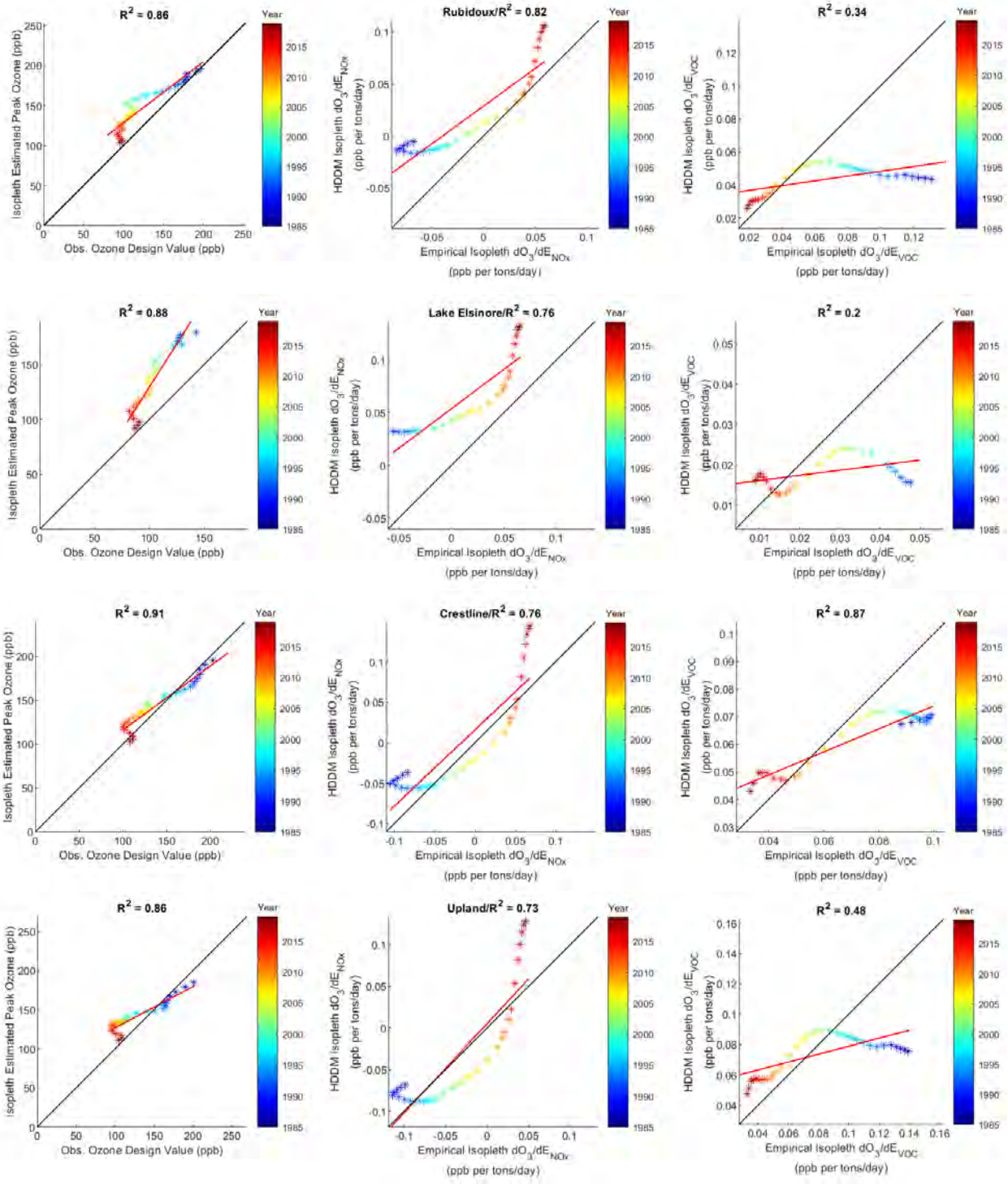
Figure L.1 The comparison between CMAQ-HDDM-derived (SRIDW method) and empirically derived ozone and sensitivities trend trajectory from 1985 to 2019. Left: The comparison between HDDM and empirically derived ozone trends; Middle: The comparison between HDDM and empirically derived ozone-to-NOx emissions first-order sensitivity trend; Right: The comparison between HDDM and empirically derived ozone-to-VOC emissions first-order sensitivity trend. The color indicates the year of the spot. The site is Azusa. Results for other sites shown below in this section follow the same layout.

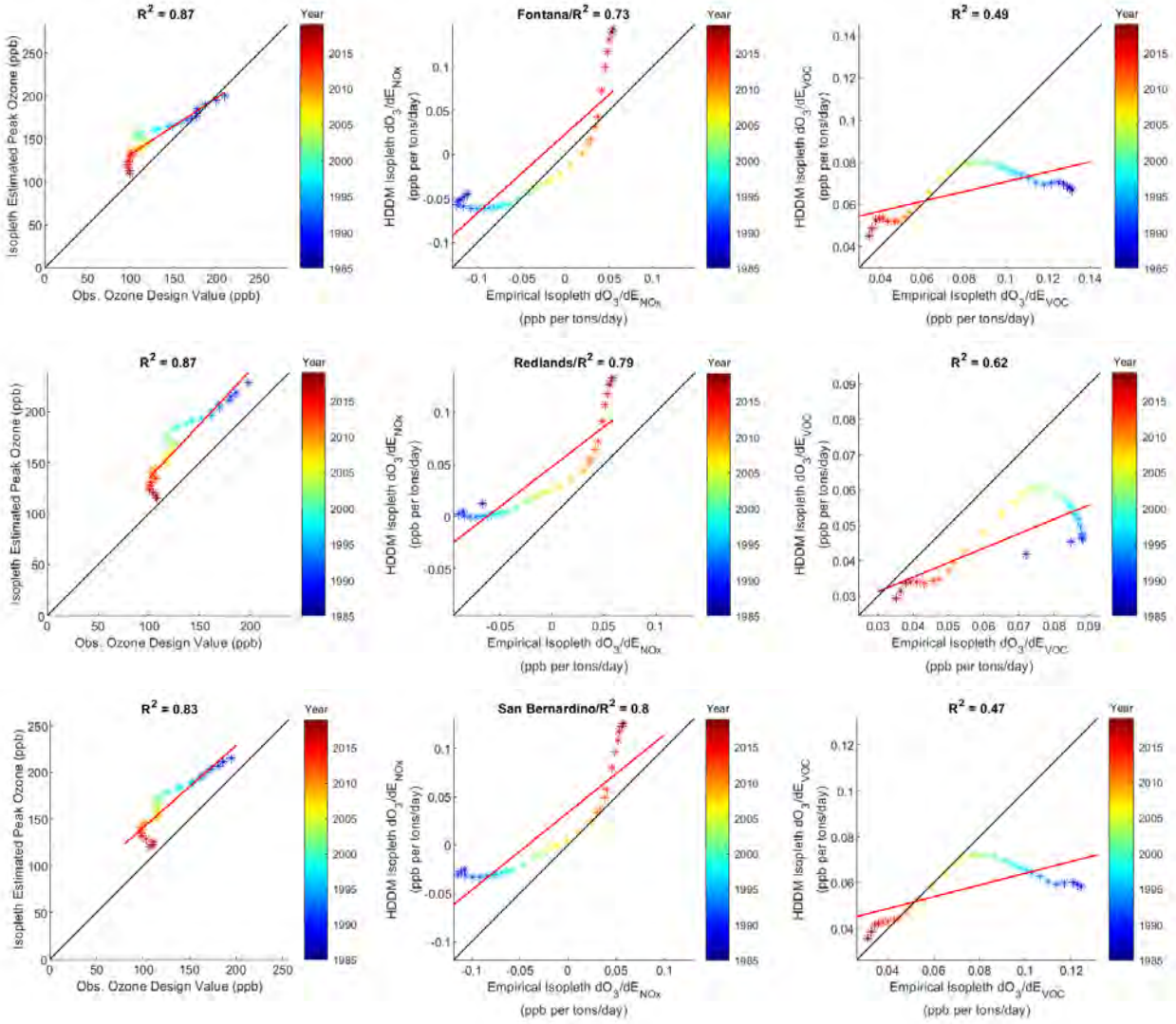

R² = 0.95
Isopleth Estimated Peak Ozone (ppb)
Obs. Ozone Design Value (ppb)
Year
Glendora/R² = 0.58
HDDM Isopleth dO3/dENOx (ppb per tons/day)
Empirical Isopleth dO3/dENOx (ppb per tons/day)
R² = 0.22
HDDM Isopleth dO3/dEVOC (ppb per tons/day)
Empirical Isopleth dO3/dEVOC (ppb per tons/day)
R² = 0.86
West LA/R² = 0.76
R² = 0.78
R² = 0.95
LA North Main/R² = 0.81
R² = 0.019
R² = 0.69
Reseda/R² = 0.73
R² = 0.17


R² = 0.79
Isopleth Estimated Peak Ozone (ppb)
Obs. Ozone Design Value (ppb)
Year
Burbank/R² = 0.94
HDDM Isopleth dO3/dENOx (ppb per tons/day)
Empirical Isopleth dO3/dENOx (ppb per tons/day)
R² = 0.44
HDDM Isopleth dO3/dEVOC (ppb per tons/day)
Empirical Isopleth dO3/dEVOC (ppb per tons/day)
R² = 0.85
Pico Rivera/R² = 0.76
R² = 0.0042
R² = 0.78
Pomona/R² = 0.72
R² = 0.49
R² = 0.92
Pasadena/R² = 0.69
R² = 0.0045


R² = 0.82
Isopleth Estimated Peak Ozone (ppb)
Obs. Ozone Design Value (ppb)
Year
Long Beach/R² = 0.64
HDDM Isopleth dO3/dENOx (ppb per tons/day)
Empirical Isopleth dO3/dENOx (ppb per tons/day)
R² = 0.074
HDDM Isopleth dO3/dEVOC (ppb per tons/day)
Empirical Isopleth dO3/dEVOC (ppb per tons/day)
R² = 0.6
LAX/R² = 0.24
R² = 0.51
R² = 0.79
Santa Clarita/R² = 0.73
R² = 0.16
R² = 0.81
Anaheim/R² = 0.84
R² = 0.0022


R² = 0.75
Isopleth Estimated Peak Ozone (ppb)
Obs. Ozone Design Value (ppb)
Year
Mission Viejo/R² = 0.77
HDDM Isopleth dO3/dENOx (ppb per tons/day)
Empirical Isopleth dO3/dENOx (ppb per tons/day)
R² = 0.2
HDDM Isopleth dO3/dEVOC (ppb per tons/day)
Empirical Isopleth dO3/dEVOC (ppb per tons/day)
R² = 0.75
La Habra/R² = 0.87
R² = 0.0025
R² = 0.67
Banning/R² = 0.76
R² = 0.075
R² = 0.79
Perris/R² = 0.78
R² = 0.074


R² = 0.86
Isopleth Estimated Peak Ozone (ppb)
Obs. Ozone Design Value (ppb)
Year
Rubidoux/R² = 0.82
HDDM Isopleth dO3/dENOx (ppb per tons/day)
Empirical Isopleth dO3/dENOx (ppb per tons/day)
R² = 0.34
HDDM Isopleth dO3/dEVOC (ppb per tons/day)
Empirical Isopleth dO3/dEVOC (ppb per tons/day)
R² = 0.88
Lake Elsinore/R² = 0.76
R² = 0.2
R² = 0.91
Crestline/R² = 0.76
R² = 0.87
R² = 0.86
Upland/R² = 0.73
R² = 0.48


R² = 0.87
Isopleth Estimated Peak Ozone (ppb)
Obs. Ozone Design Value (ppb)
Year
Fontana/R² = 0.73
HDDM isopleth dO3/dENOx (ppb per tons/day)
Empirical Isopleth dO3/dENOx (ppb per tons/day)
R² = 0.49
HDDM isopleth dO3/dEVOC (ppb per tons/day)
Empirical Isopleth dO3/dEVOC (ppb per tons/day)
R² = 0.87
Redlands/R² = 0.79
R² = 0.62
R² = 0.83
San Bernardino/R² = 0.8
R² = 0.47

Appendix M: Comparison of Ozone Concentrations and NOx and VOC Emissions Sensitivities between the CMAQ-HDDM Quadratic Fitting Isopleths and Empirically Based Isopleths over Time for Historical Emissions Level

A further evaluation of the differences between CMAQ-derived isopleths and the empirically derived isopleths can be made by comparing the estimated historical trends (along emissions trajectories) of ozone concentrations and ozone-to-emissions sensitivities. Using the isopleth, we were able to produce the trajectory for both ozone concentrations and sensitivities, which can be a good representation of how well the CTM captures the historical trends of the ozone response to emissions changes. We show the comparison between quadratic-fitting-based estimation and empirically based estimation of ozone and sensitivities for each individual monitoring site.

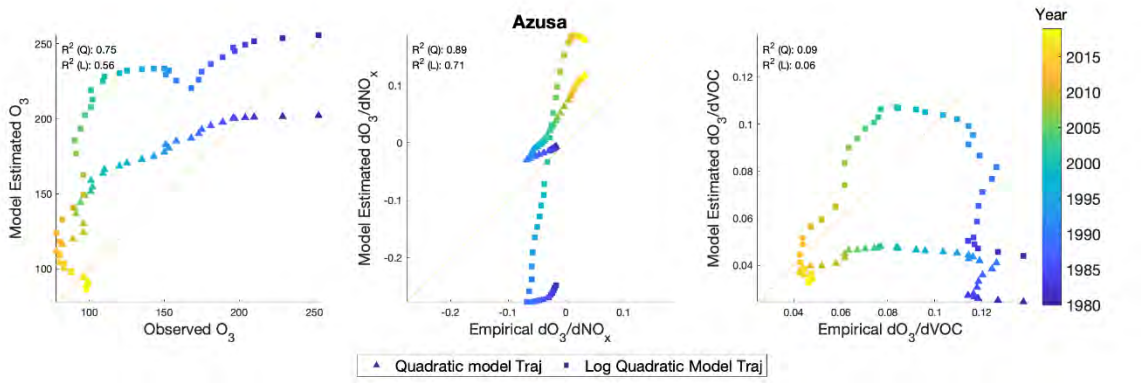
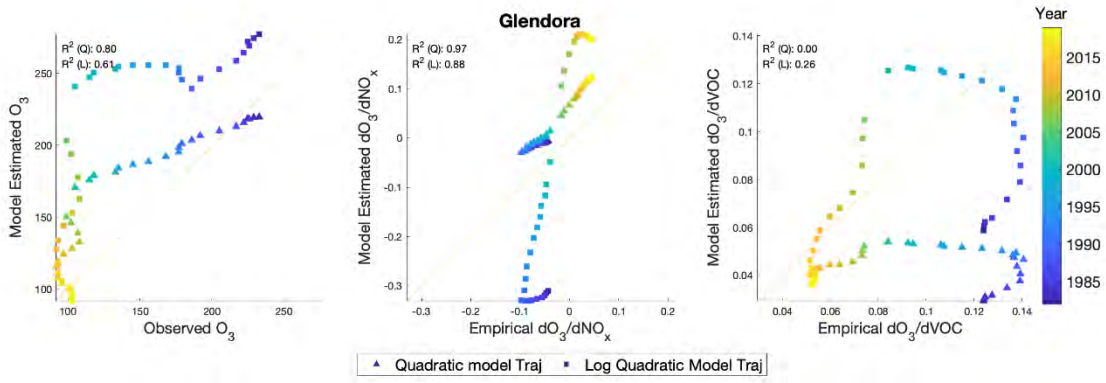
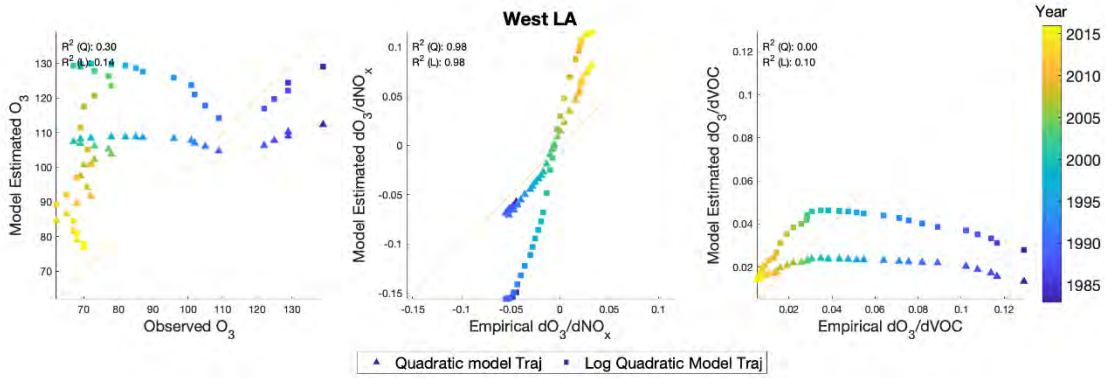
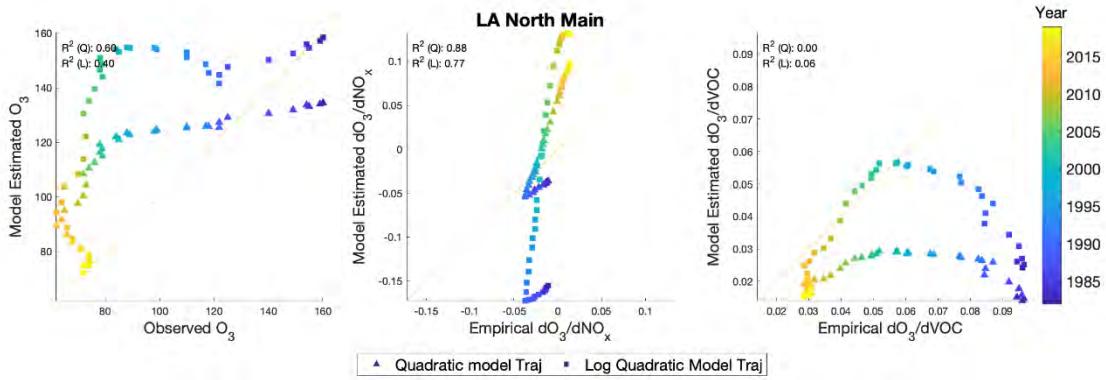
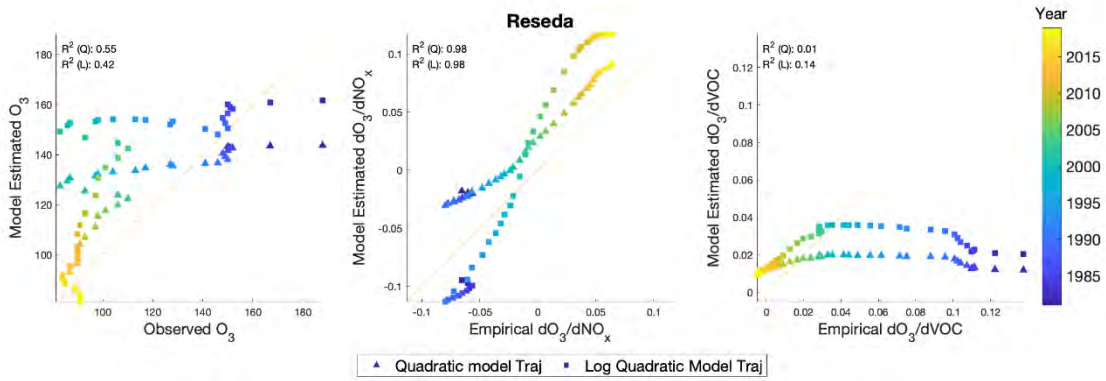


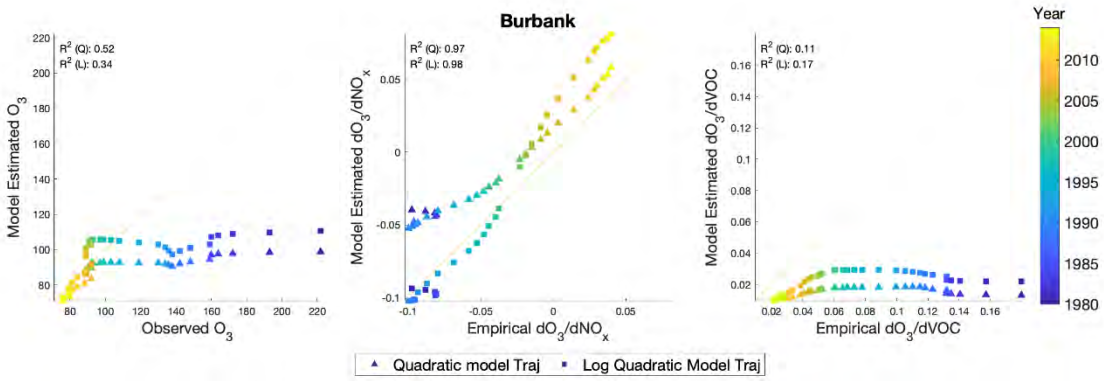
Figure M.1 The comparison between CMAQ-HDDM-derived (quadratic-fitting method) and empirically derived ozone and sensitivities trend trajectory from 1985 to 2019. Left: The comparison between CMAQ-HDDM and empirically derived ozone trends; Middle: The comparison between HDDM and empirically derived ozone-to-NOx emissions first-order sensitivity trend; Right: The comparison between HDDM and empirically derived ozone-to-VOC emissions first-order sensitivity trend. The color indicates the year of the spot. The site is Azusa. Results for other sites shown below in this section follow the same layout.

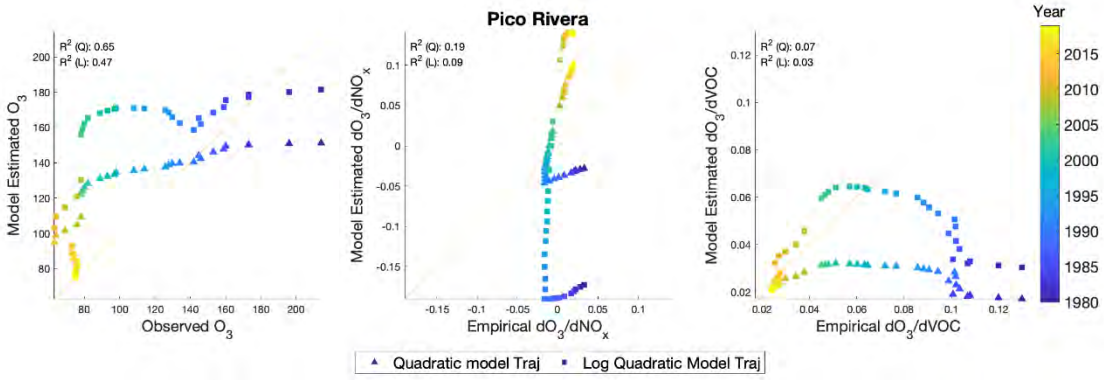

Glendora
R² (Q): 0.80
R² (L): 0.61
Model Estimated O3
Observed O3
R² (Q): 0.97
R² (L): 0.88
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.00
R² (L): 0.26
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

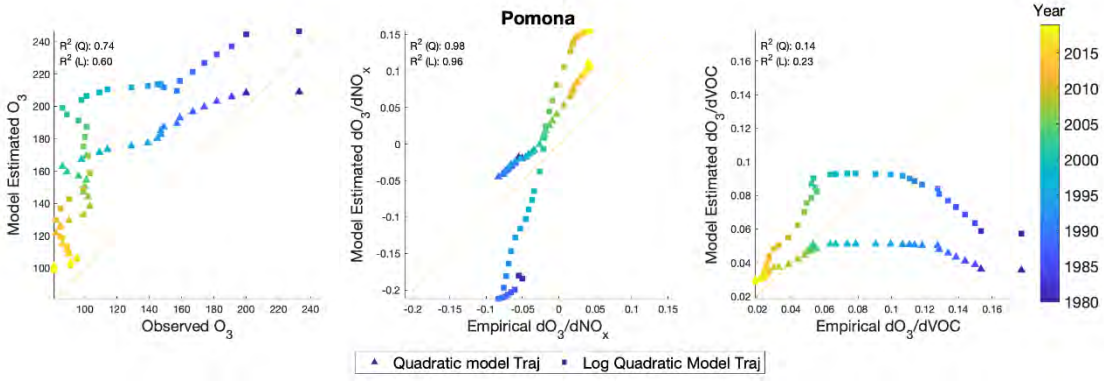

West LA
R² (Q): 0.30
R² (L): 0.14
Model Estimated O3
Observed O3
R² (Q): 0.98
R² (L): 0.98
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.00
R² (L): 0.10
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

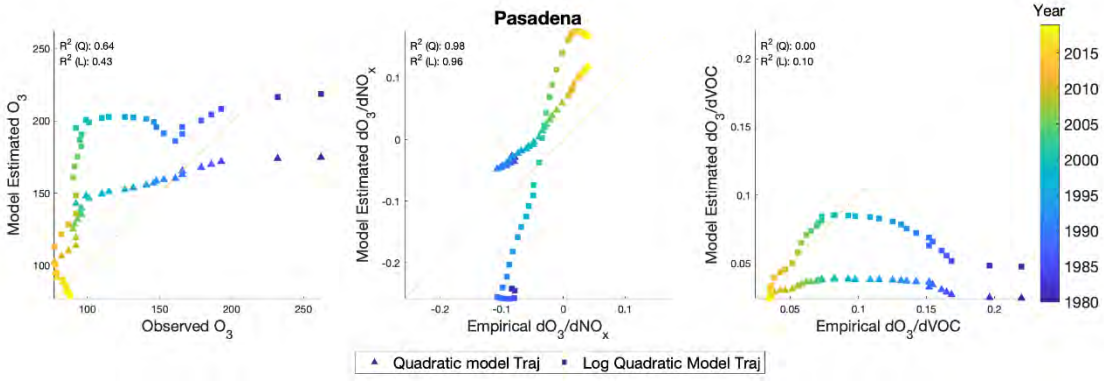

LA North Main
R² (Q): 0.69
R² (L): 0.40
Model Estimated O3
Observed O3
R² (Q): 0.88
R² (L): 0.77
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.00
R² (L): 0.06
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

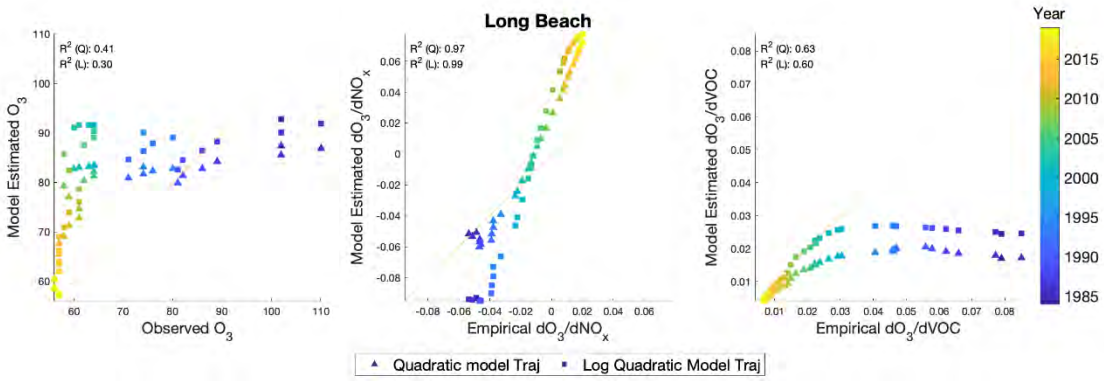

Reseda
R² (Q): 0.55
R² (L): 0.42
Model Estimated O3
Observed O3
R² (Q): 0.98
R² (L): 0.98
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.01
R² (L): 0.14
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

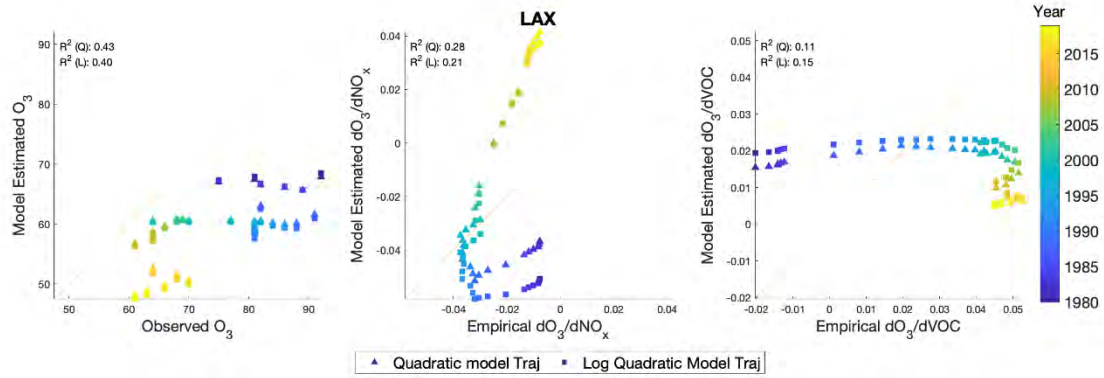

Burbank
R² (Q): 0.52
R² (L): 0.34
R² (Q): 0.97
R² (L): 0.98
R² (Q): 0.11
R² (L): 0.17
Model Estimated O3
Observed O3
Model Estimated dO3/dNOx
Empirical dO3/dNOx
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
Quadratic model Traj
Log Quadratic Model Traj

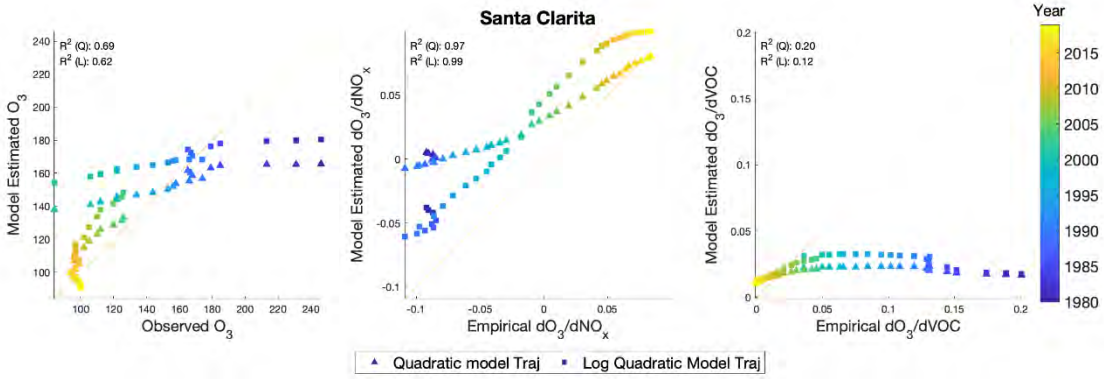

Pico Rivera
R² (Q): 0.65
R² (L): 0.47
R² (Q): 0.19
R² (L): 0.09
R² (Q): 0.07
R² (L): 0.03
Model Estimated O3
Observed O3
Model Estimated dO3/dNOx
Empirical dO3/dNOx
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
Quadratic model Traj
Log Quadratic Model Traj

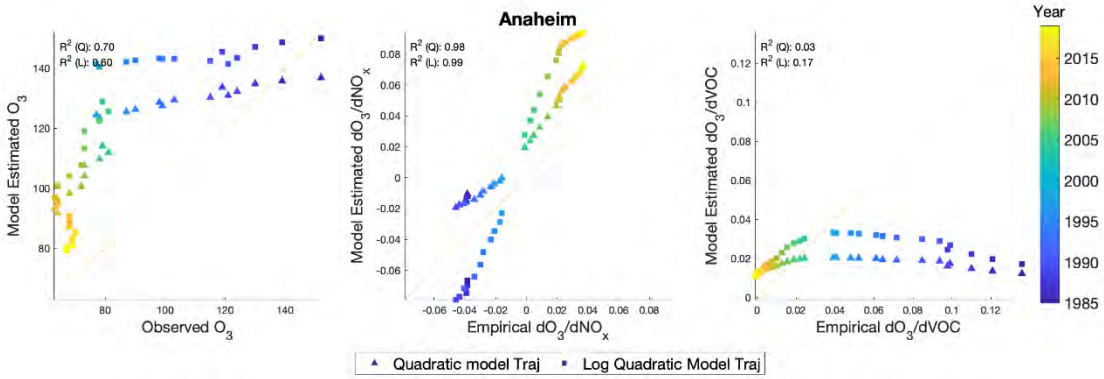

Pomona
R² (Q): 0.74
R² (L): 0.60
R² (Q): 0.98
R² (L): 0.96
R² (Q): 0.14
R² (L): 0.23
Model Estimated O3
Observed O3
Model Estimated dO3/dNOx
Empirical dO3/dNOx
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
Quadratic model Traj
Log Quadratic Model Traj

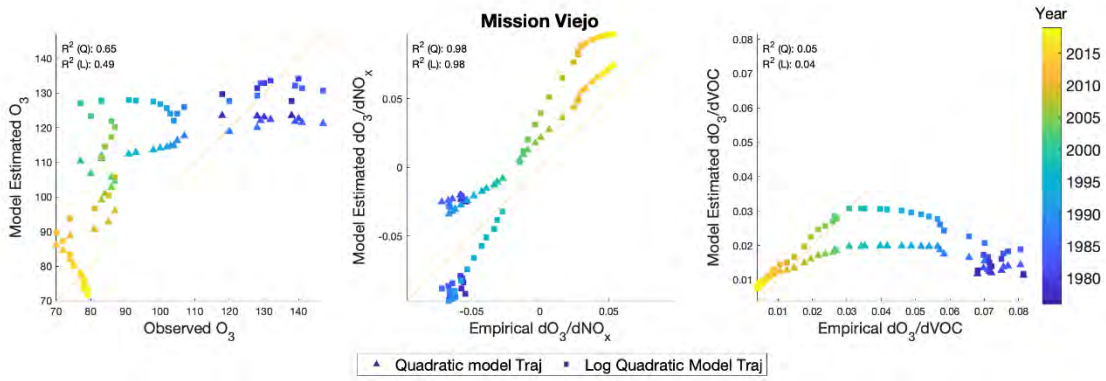

Pasadena
R² (Q): 0.64
R² (L): 0.43
R² (Q): 0.98
R² (L): 0.96
R² (Q): 0.00
R² (L): 0.10
Model Estimated O3
Observed O3
Model Estimated dO3/dNOx
Empirical dO3/dNOx
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
Quadratic model Traj
Log Quadratic Model Traj

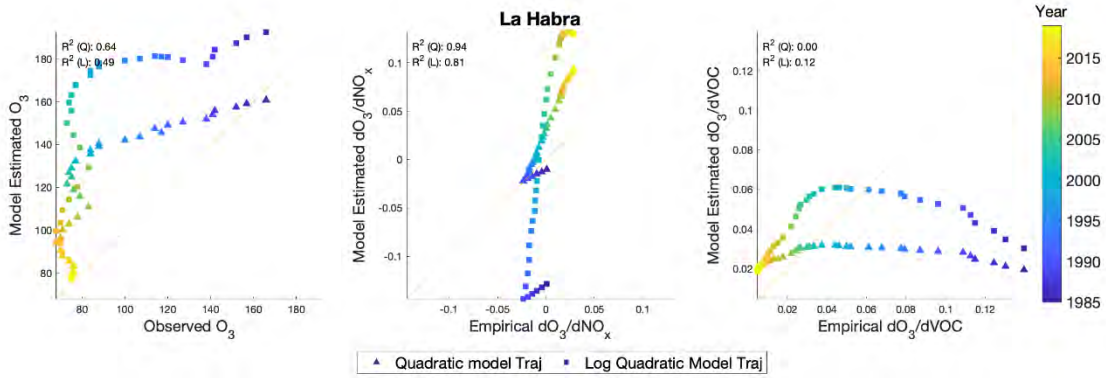

Long Beach
R² (Q): 0.41
R² (L): 0.30
Model Estimated O3
Observed O3
R² (Q): 0.97
R² (L): 0.99
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.63
R² (L): 0.60
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

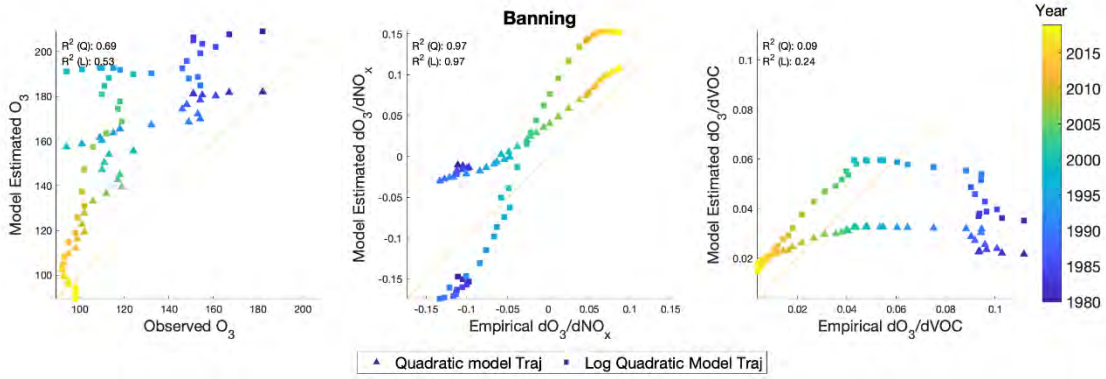

LAX
R² (Q): 0.43
R² (L): 0.40
Model Estimated O3
Observed O3
R² (Q): 0.28
R² (L): 0.21
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.11
R² (L): 0.15
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj

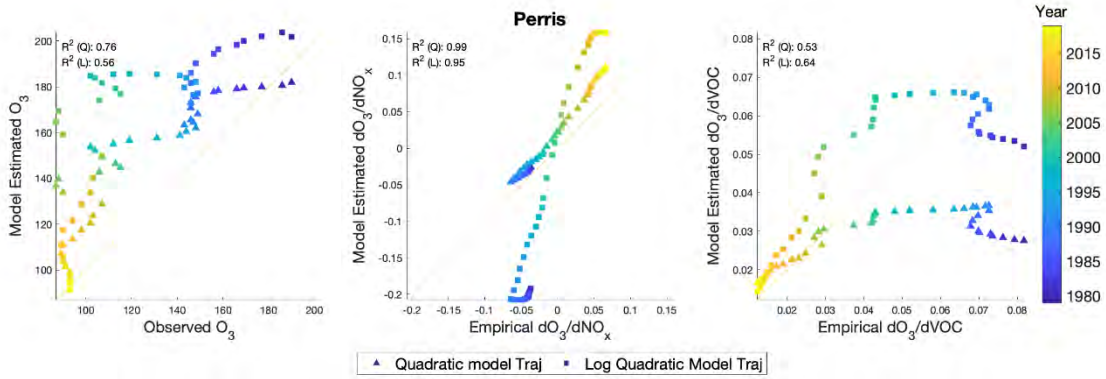

Santa Clarita
R² (Q): 0.69
R² (L): 0.62
Model Estimated O3
Observed O3
R² (Q): 0.97
R² (L): 0.99
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.20
R² (L): 0.12
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj

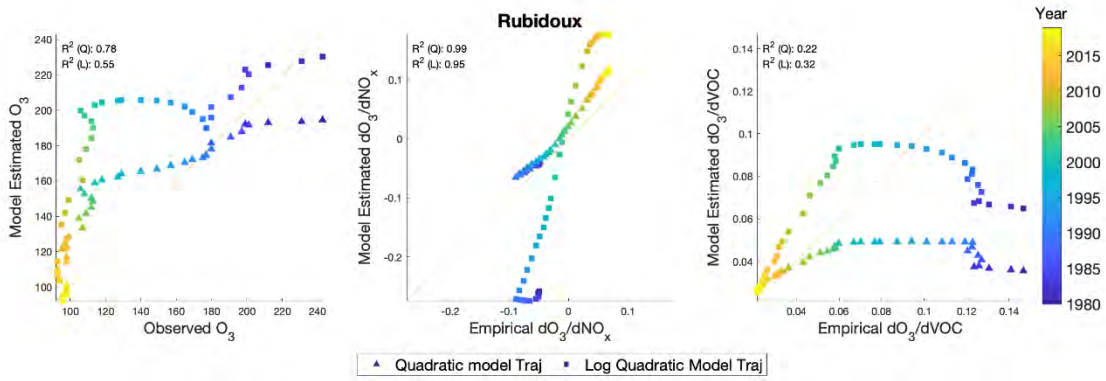

Anaheim
R² (Q): 0.70
R² (L): 0.60
Model Estimated O3
Observed O3
R² (Q): 0.98
R² (L): 0.99
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.03
R² (L): 0.17
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

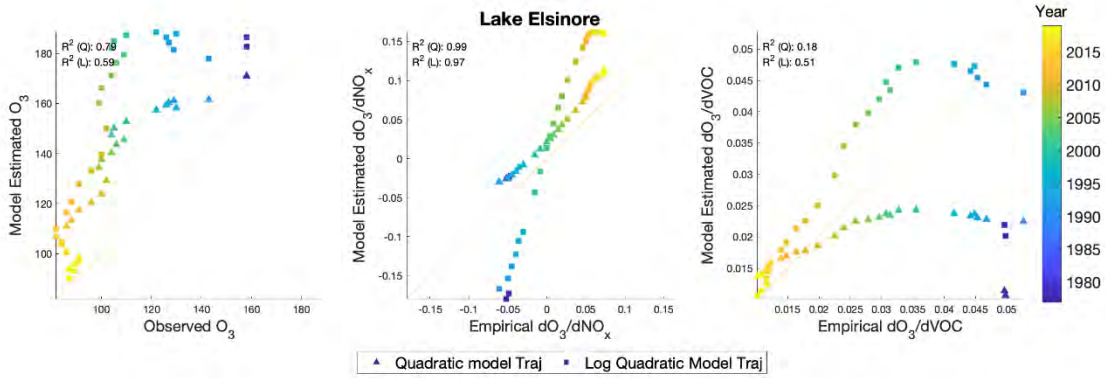

Mission Viejo
R² (Q): 0.65
R² (L): 0.49
Model Estimated O3
Observed O3
R² (Q): 0.98
R² (L): 0.98
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.05
R² (L): 0.04
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj

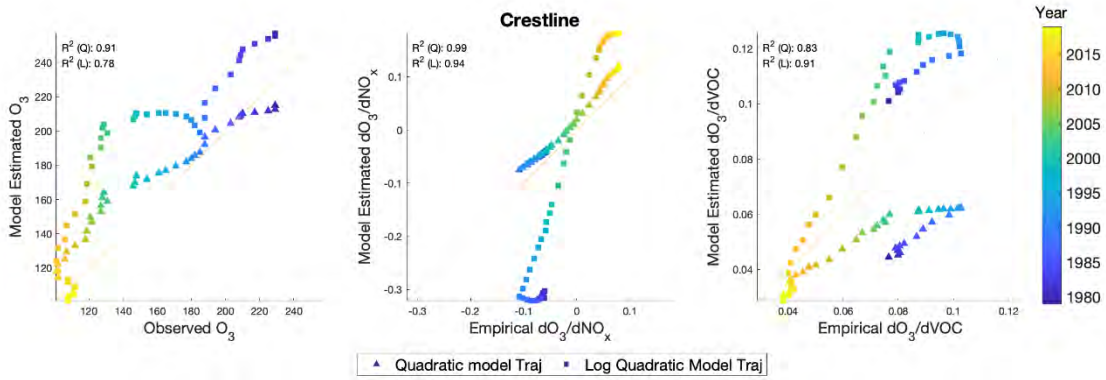

La Habra
R² (Q): 0.64
R² (L): 0.49
Model Estimated O3
Observed O3
R² (Q): 0.94
R² (L): 0.81
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.00
R² (L): 0.12
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
Quadratic model Traj
Log Quadratic Model Traj

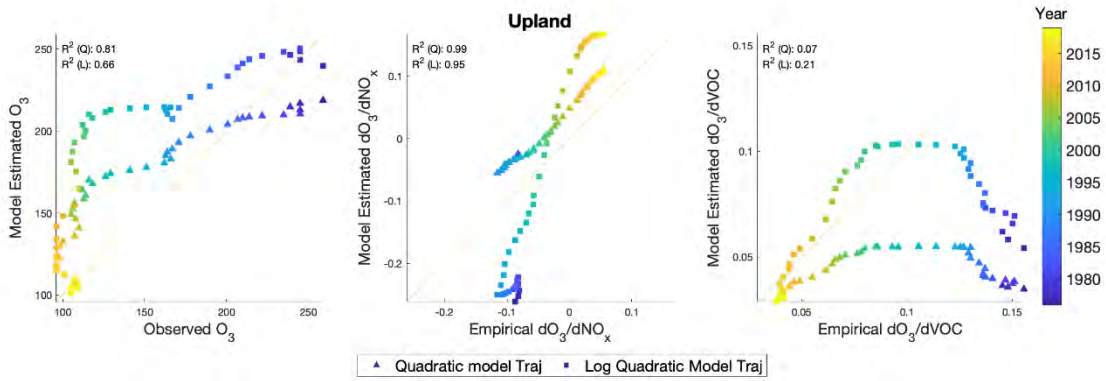

Banning
R² (Q): 0.69
R² (L): 0.53
Model Estimated O3
Observed O3
R² (Q): 0.97
R² (L): 0.97
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.09
R² (L): 0.24
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj

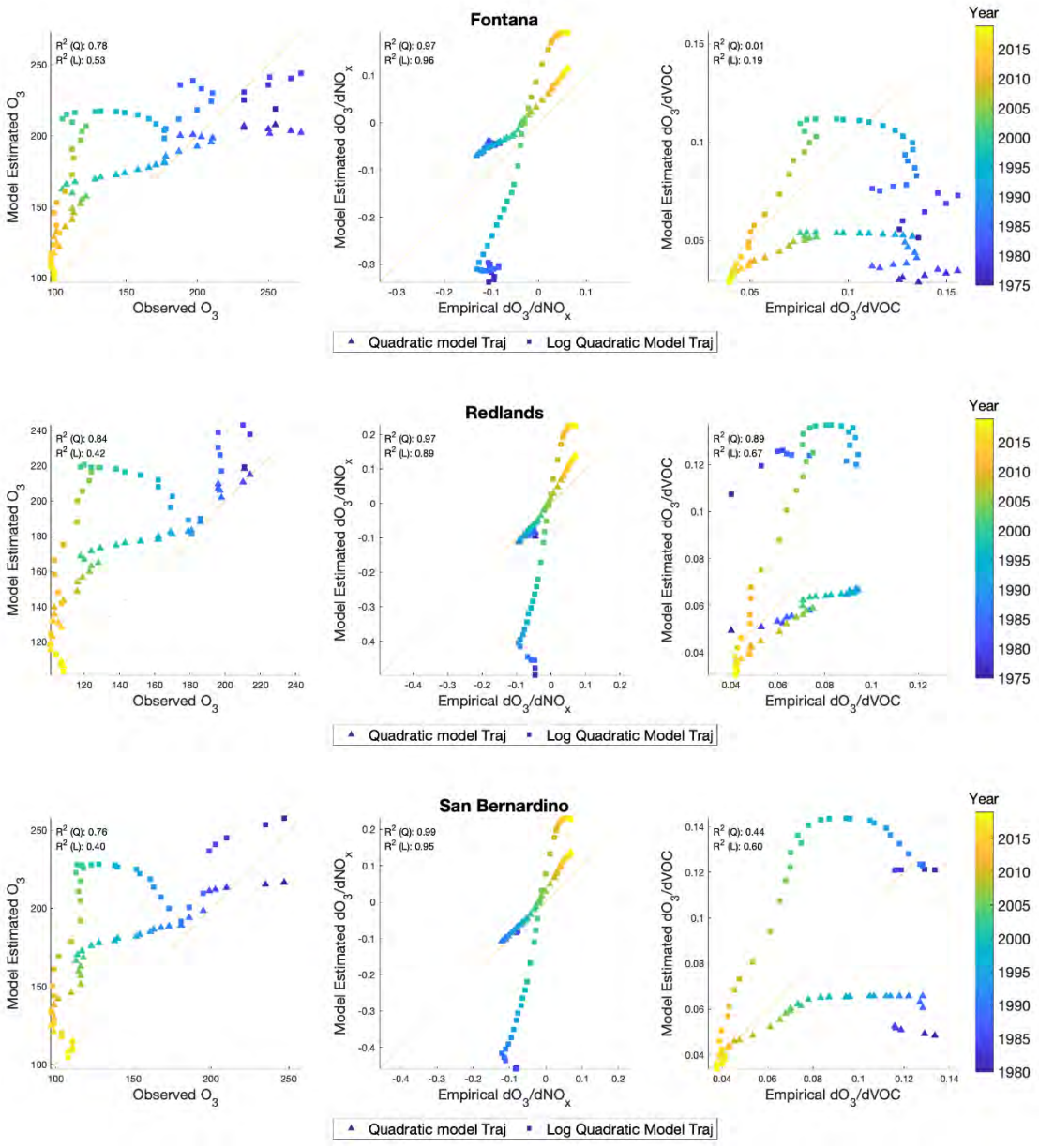

Perris
R² (Q): 0.76
R² (L): 0.56
Model Estimated O3
Observed O3
R² (Q): 0.99
R² (L): 0.95
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.53
R² (L): 0.64
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj


Rubidoux
R² (Q): 0.78
R² (L): 0.55
Model Estimated O3
Observed O3
R² (Q): 0.99
R² (L): 0.95
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.22
R² (L): 0.32
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj


Lake Elsinore
R² (Q): 0.79
R² (L): 0.59
Model Estimated O3
Observed O3
R² (Q): 0.99
R² (L): 0.97
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.18
R² (L): 0.51
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj


Crestline
R² (Q): 0.91
R² (L): 0.78
Model Estimated O3
Observed O3
R² (Q): 0.99
R² (L): 0.94
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.83
R² (L): 0.91
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj


Upland
R² (Q): 0.81
R² (L): 0.66
Model Estimated O3
Observed O3
R² (Q): 0.99
R² (L): 0.95
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.07
R² (L): 0.21
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
Quadratic model Traj
Log Quadratic Model Traj


Fontana
R² (Q): 0.78
R² (L): 0.53
Model Estimated O3
Observed O3
R² (Q): 0.97
R² (L): 0.96
Model Estimated dO3/dNOx
Empirical dO3/dNOx
R² (Q): 0.01
R² (L): 0.19
Model Estimated dO3/dVOC
Empirical dO3/dVOC
Year
2015
2010
2005
2000
1995
1990
1985
1980
1975
Quadratic model Traj
Log Quadratic Model Traj
Redlands
R² (Q): 0.84
R² (L): 0.42
R² (Q): 0.97
R² (L): 0.89
R² (Q): 0.89
R² (L): 0.67
San Bernardino
R² (Q): 0.76
R² (L): 0.40
R² (Q): 0.99
R² (L): 0.95
R² (Q): 0.44
R² (L): 0.60

Appendix N: Spatial Distribution Plots of Daily CMAQ-HDDM Simulated Ozone Concentration and First- and Second-Order Sensitivities to NOx and VOC Emissions

We show the spatial distribution plots of daily CMAQ-HDDM simulated ozone concentration and first- and second-Order sensitivities to NOx and VOC emissions over the LA4 simulation domain. Each plot shows the results for each individual simulation day for different emissions scenarios of year 1985, 2001, 2011, 2016, 2028, and one percent of 2016 emissions.

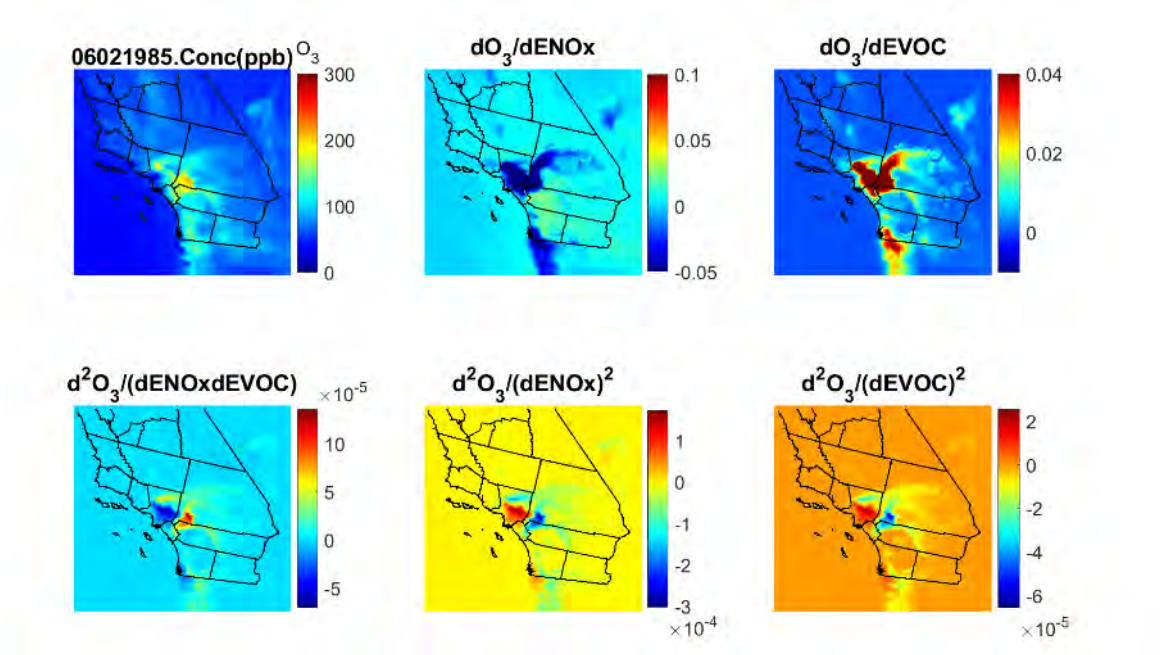
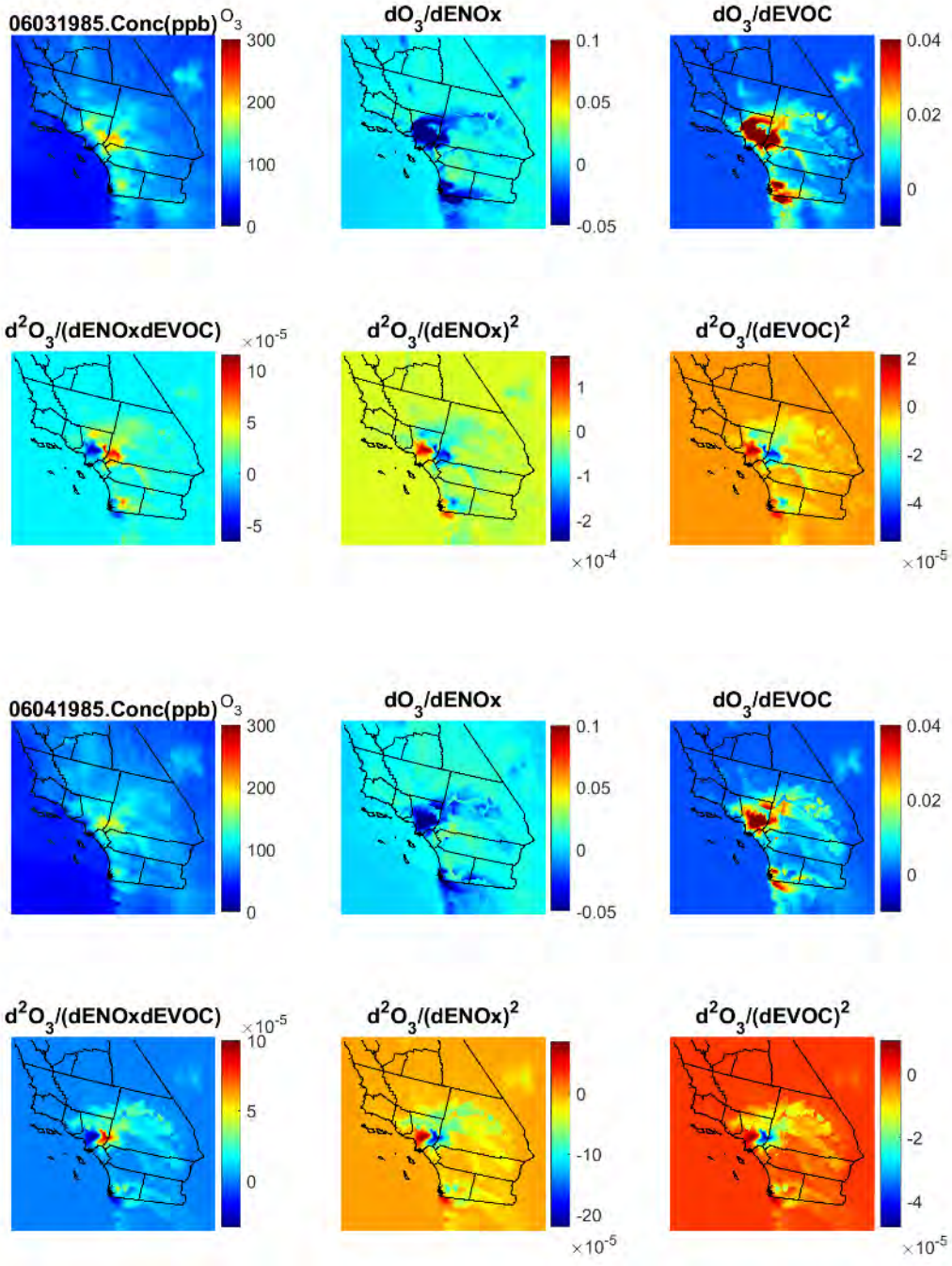
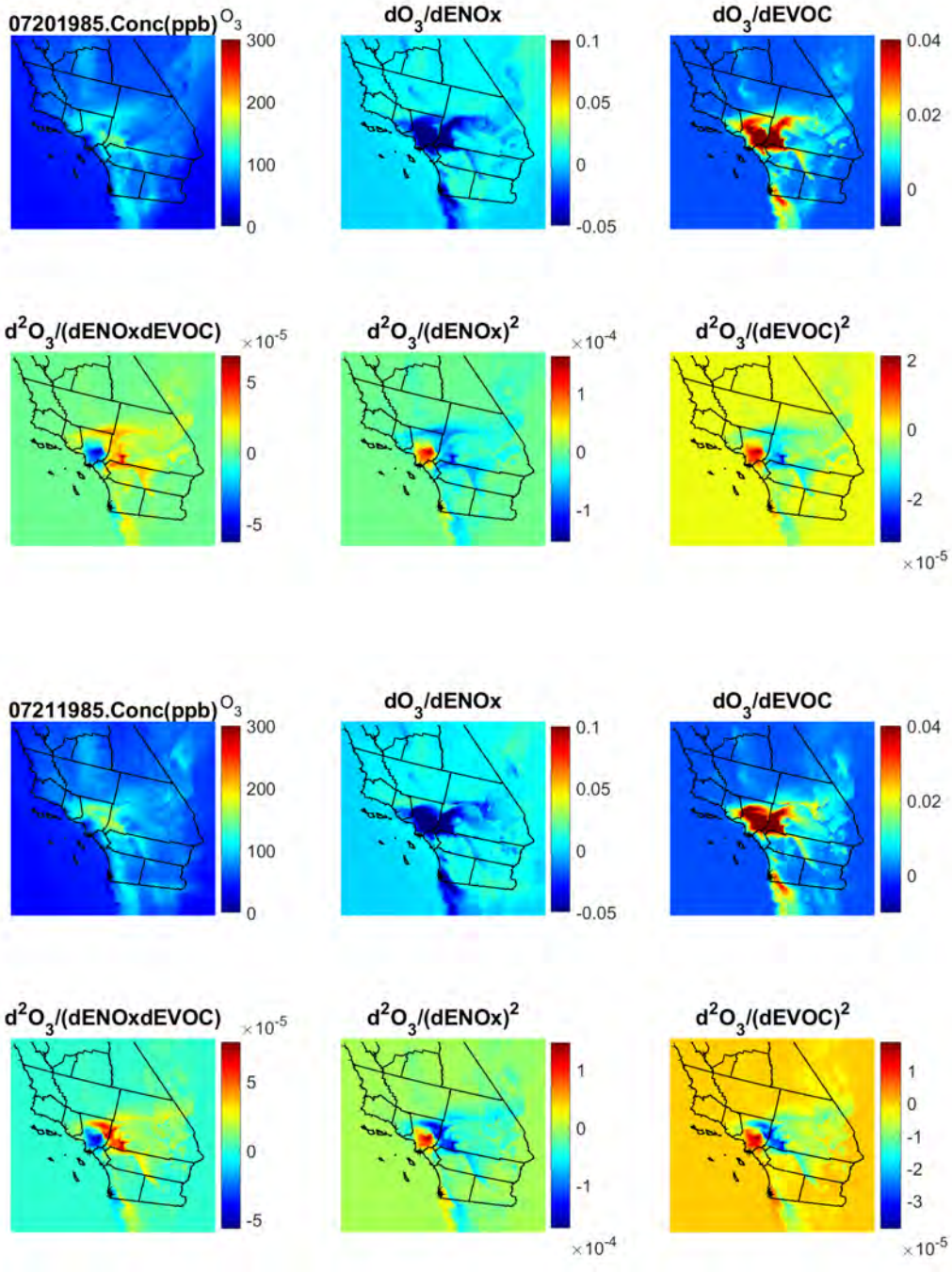
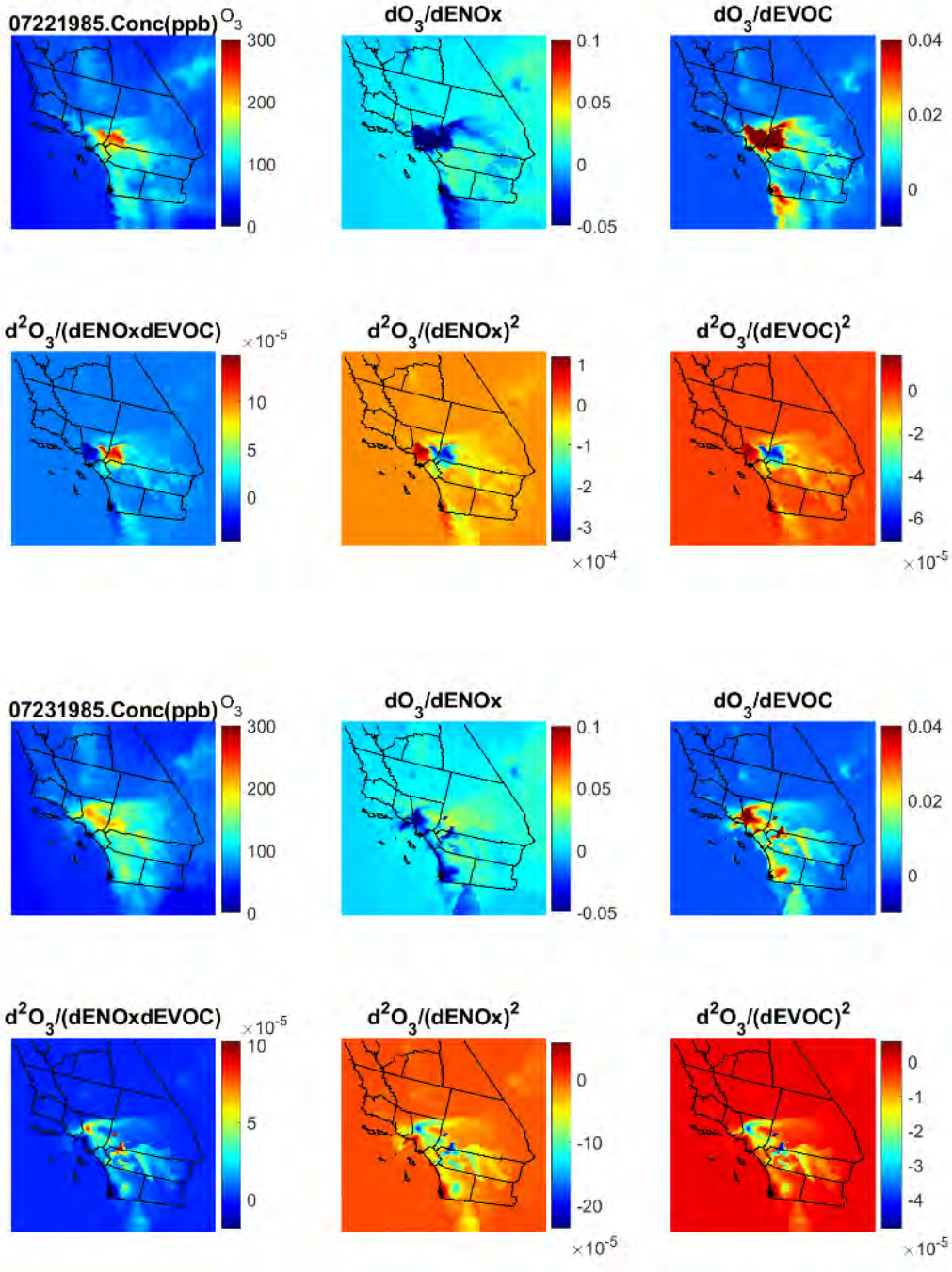
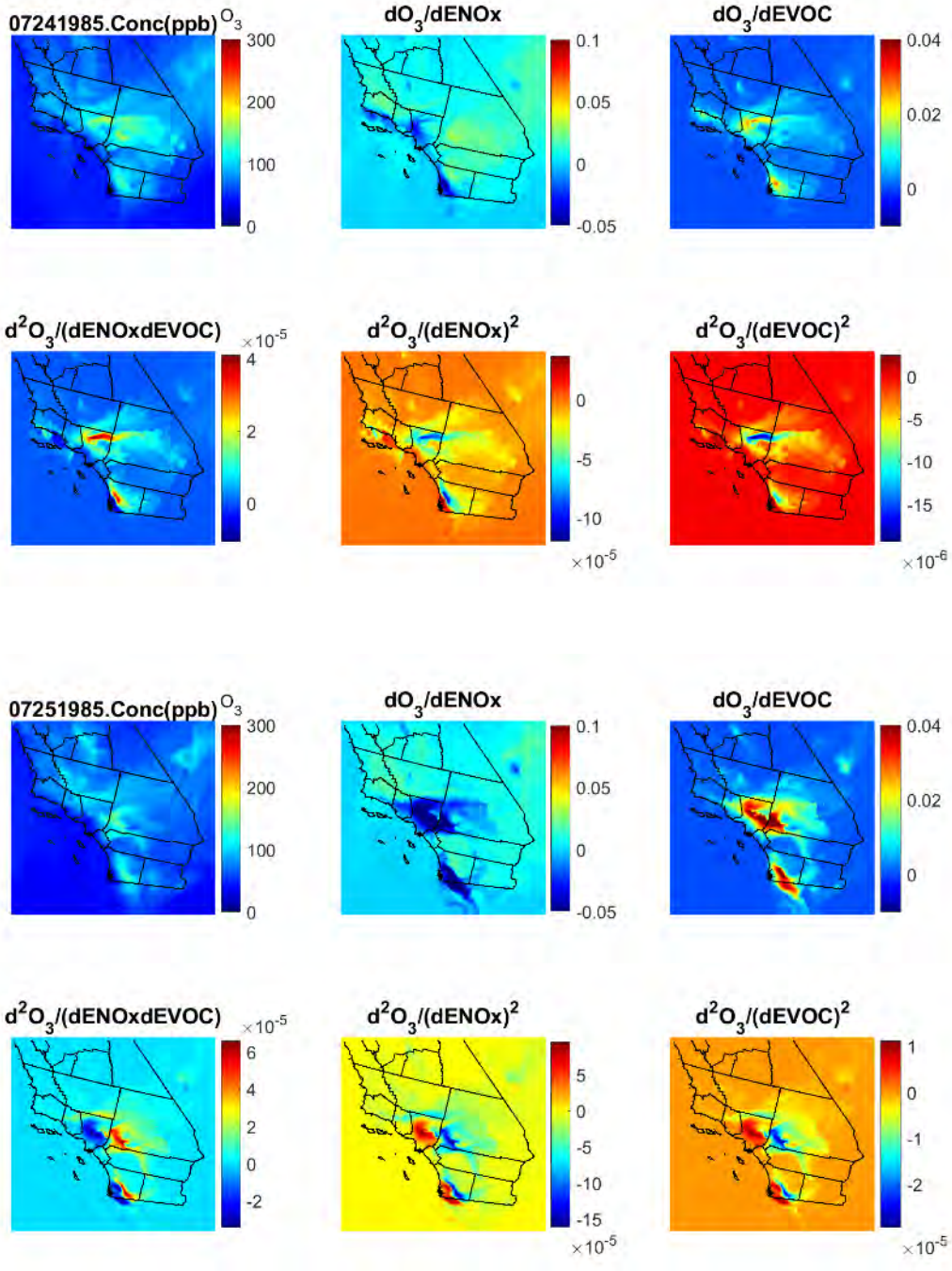


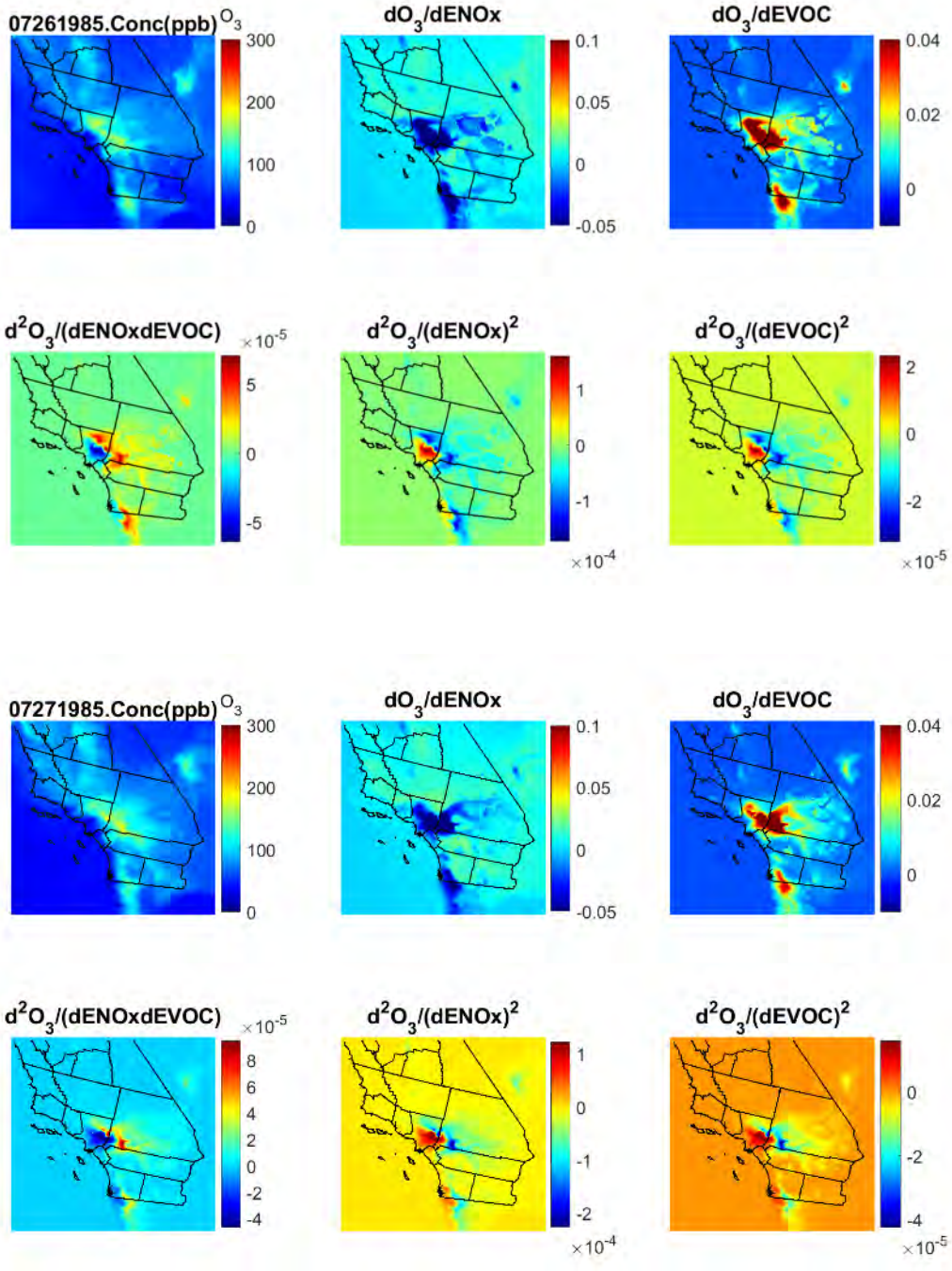
Figure N.1 Spatial distribution of daily CMAQ-HDDM simulated ozone concentration and first- and second-Order sensitivities to NOx and VOC emissions over the LA4 simulation domain. The title of each sub-plot indicates the values being plotted. The date is June 2, 1985. Results for other date and years shown below in this section follow the same layout. The title of the upper-left sub-plot indicates the date and year of the simulation results being showed.

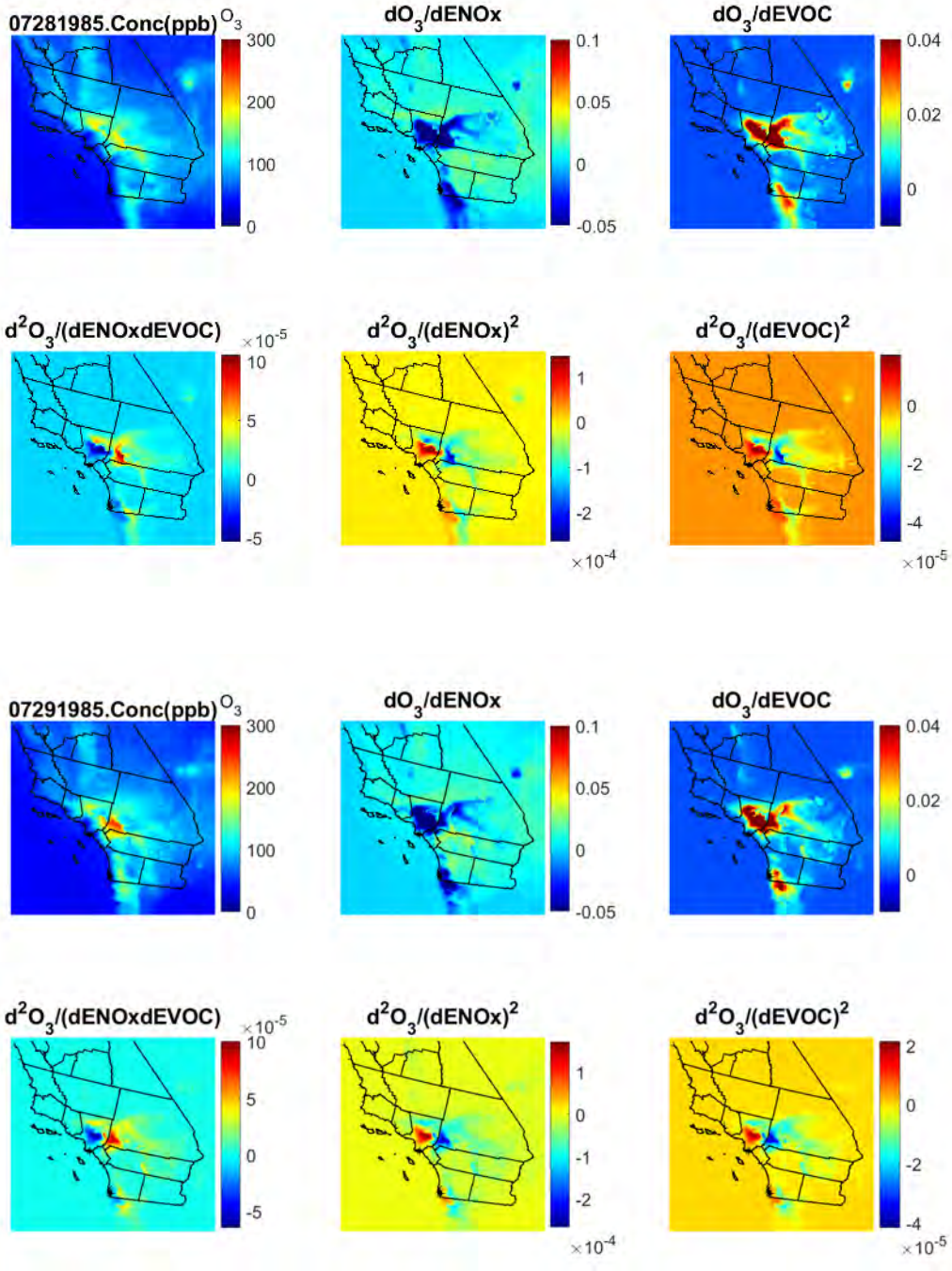

06031985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
-5
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
×10-5
06041985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
d2O3/(dENOx)2
0
-10
-20
×10-5
d2O3/(dEVOC)2
0
-2
-4
×10-5

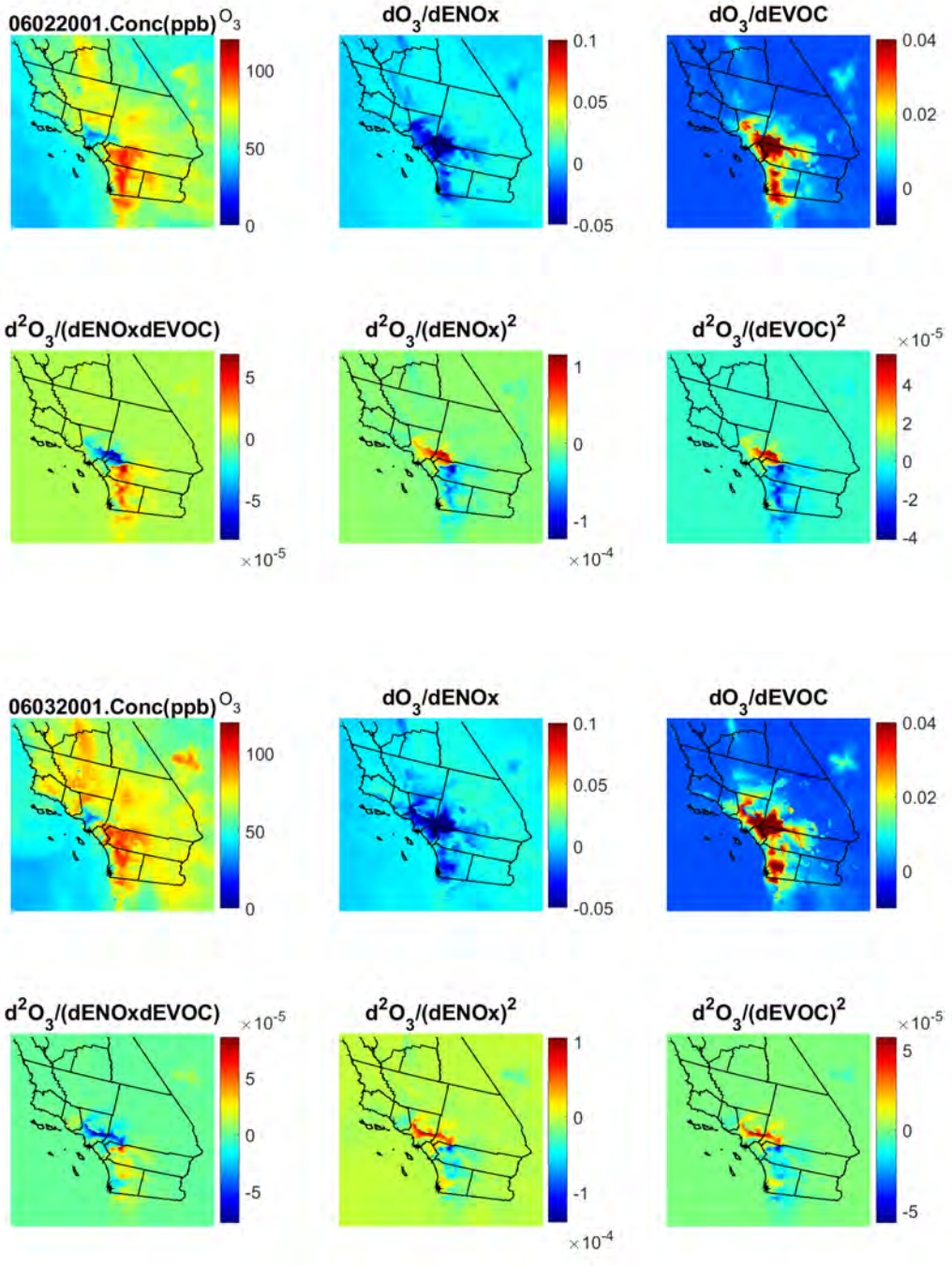

07201985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
5
0
-5
d2O3/(dENOx)2
×10-4
1
0
-1
d2O3/(dEVOC)2
2
0
-2
×10-5
07211985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
5
0
-5
d2O3/(dENOx)2
1
0
-1
×10-4
d2O3/(dEVOC)2
1
0
-1
-2
-3
×10-5

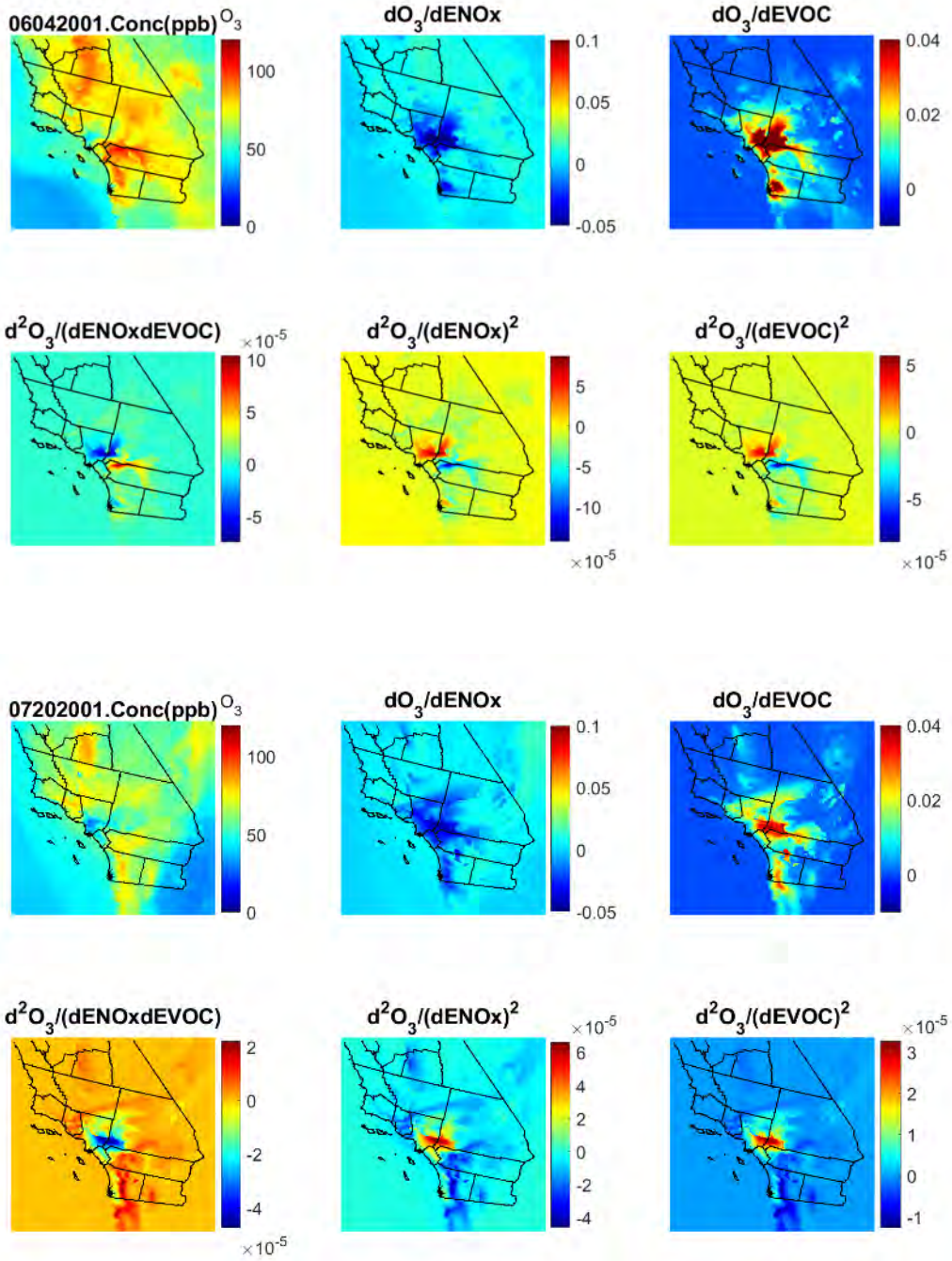

07221985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
d2O3/(dENOx)2
1
0
-1
-2
-3
×10-4
d2O3/(dEVOC)2
0
-2
-4
-6
×10-5
07231985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
d2O3/(dENOx)2
0
-10
-20
×10-5
d2O3/(dEVOC)2
0
-1
-2
-3
-4
×10-5

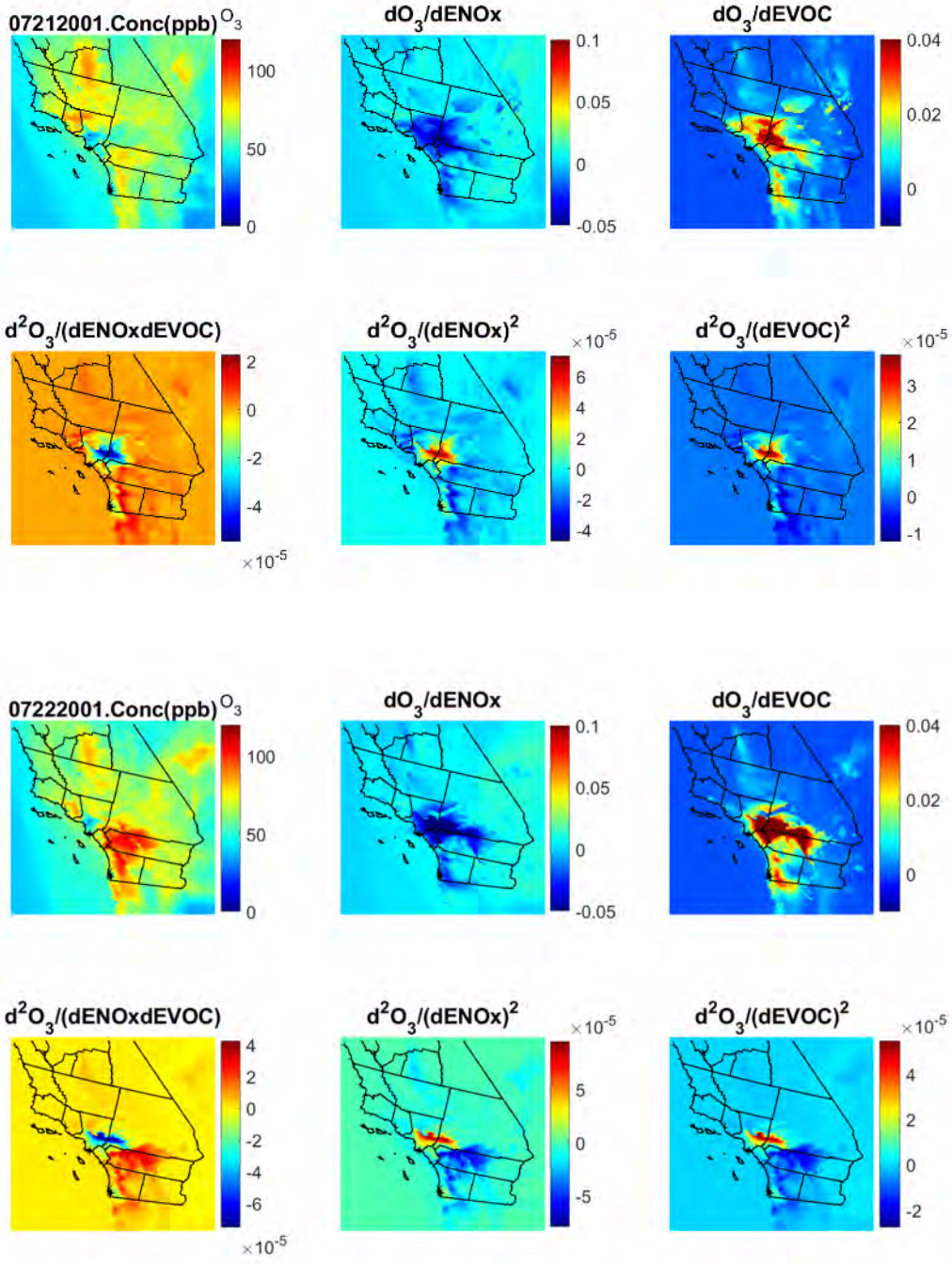

07241985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
4
2
0
d2O3/(dENOx)2
0
-5
-10
×10-5
d2O3/(dEVOC)2
0
-5
-10
-15
×10-6
07251985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
6
4
2
0
-2
d2O3/(dENOx)2
5
0
-5
-10
-15
×10-5
d2O3/(dEVOC)2
1
0
-1
-2
×10-5

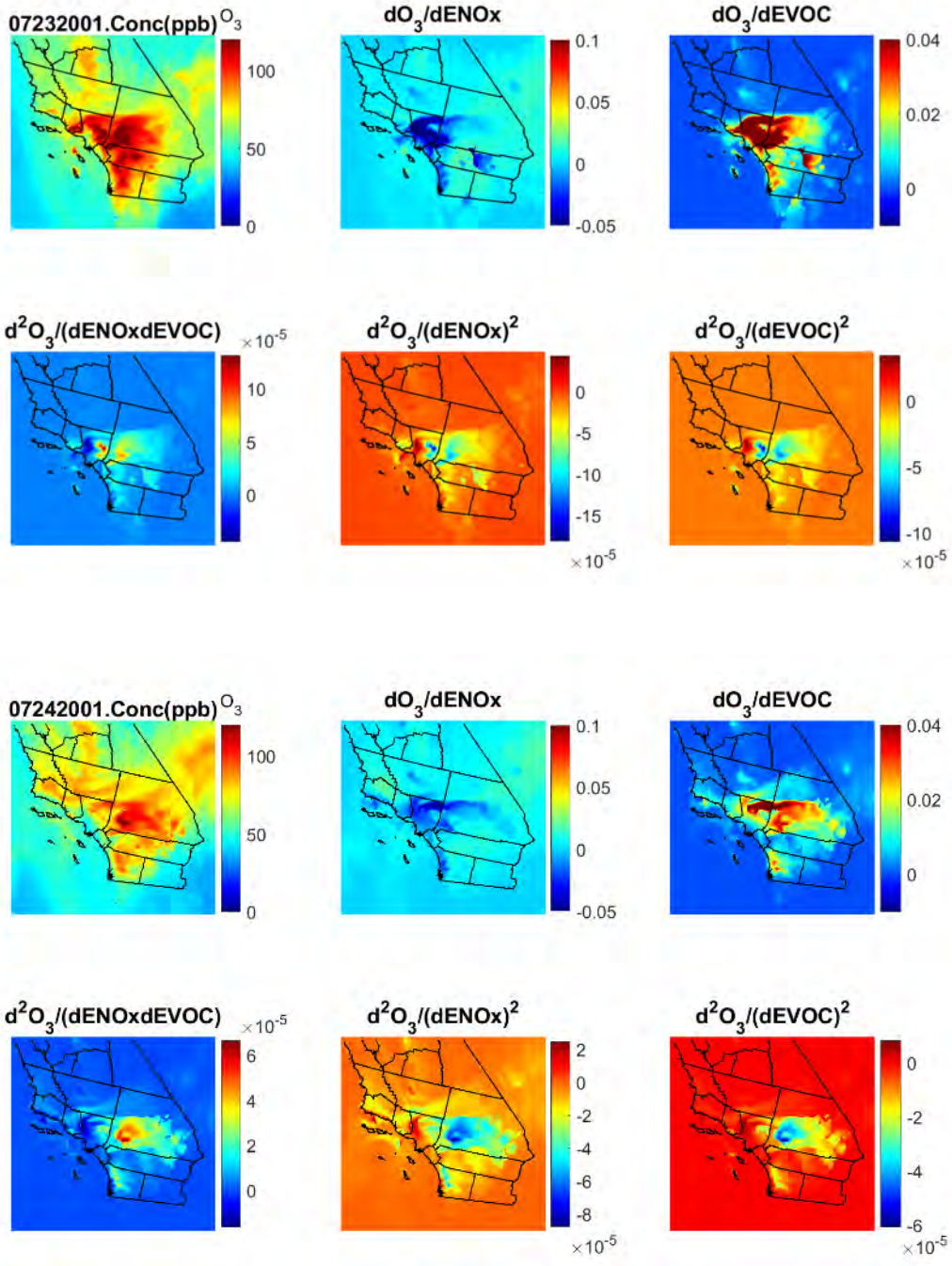

07261985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
5
0
-5
d2O3/(dENOx)2
1
0
-1
×10-4
d2O3/(dEVOC)2
2
0
-2
×10-5
07271985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
8
6
4
2
0
-2
-4
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
0
-2
-4
×10-5

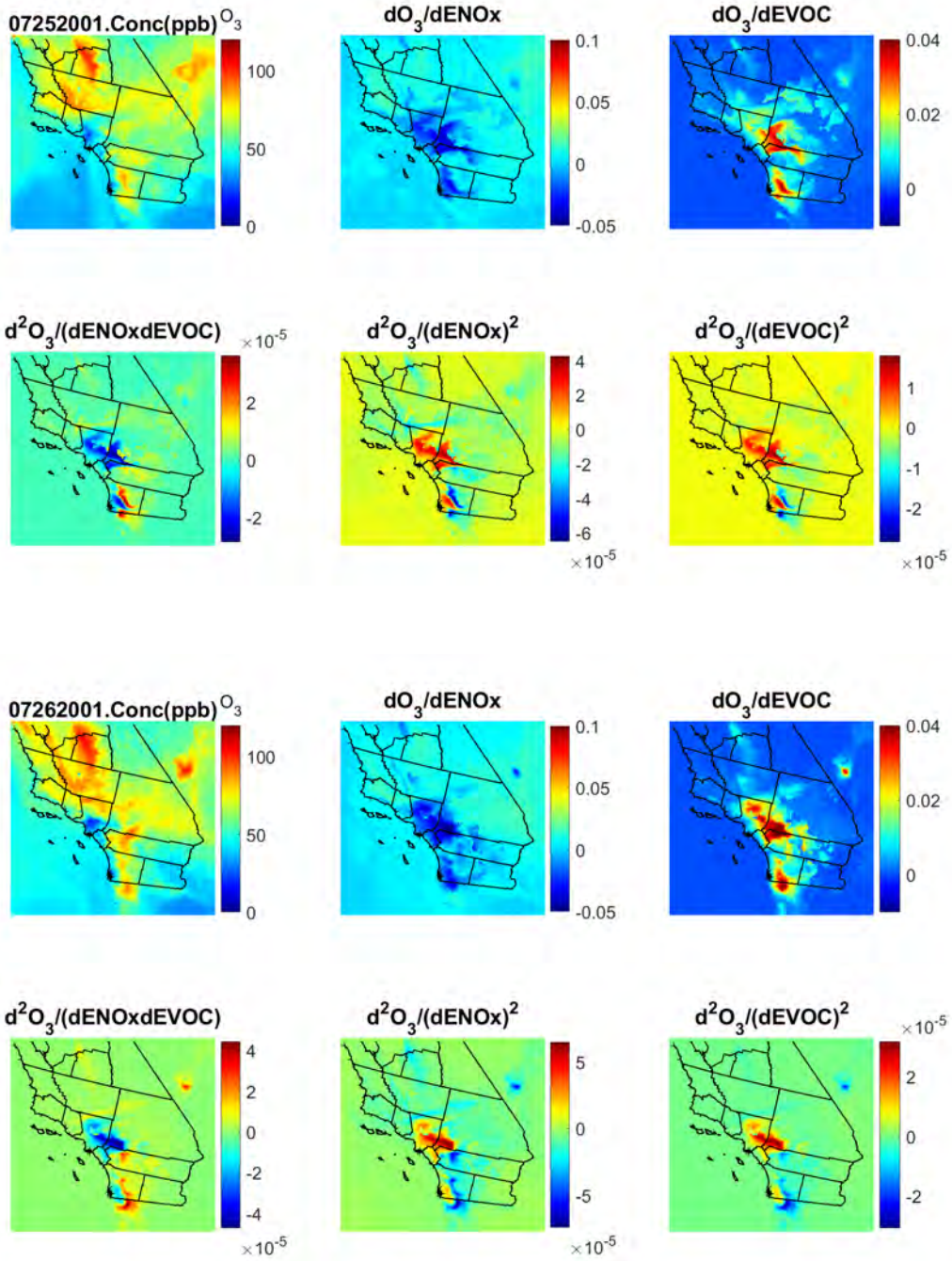

07281985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
-5
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
0
-2
-4
×10-5
07291985.Conc(ppb) O3
300
200
100
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
-5
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
×10-5

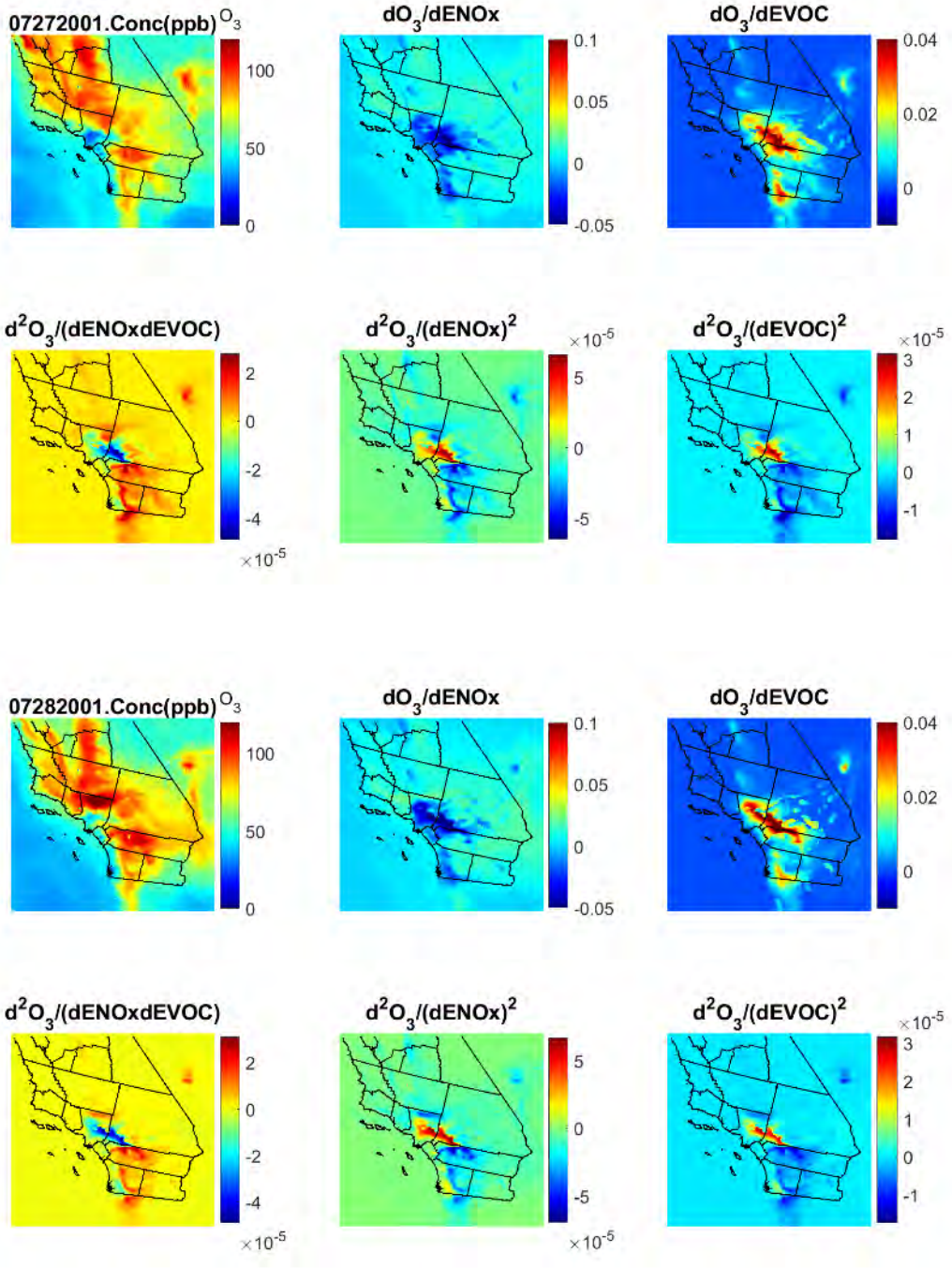

06022001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
5
0
-5
×10-5
d2O3/(dENOx)2
1
0
-1
×10-4
d2O3/(dEVOC)2
×10-5
4
2
0
-2
-4
06032001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
5
0
-5
d2O3/(dENOx)2
1
0
-1
×10-4
d2O3/(dEVOC)2
×10-5
5
0
-5

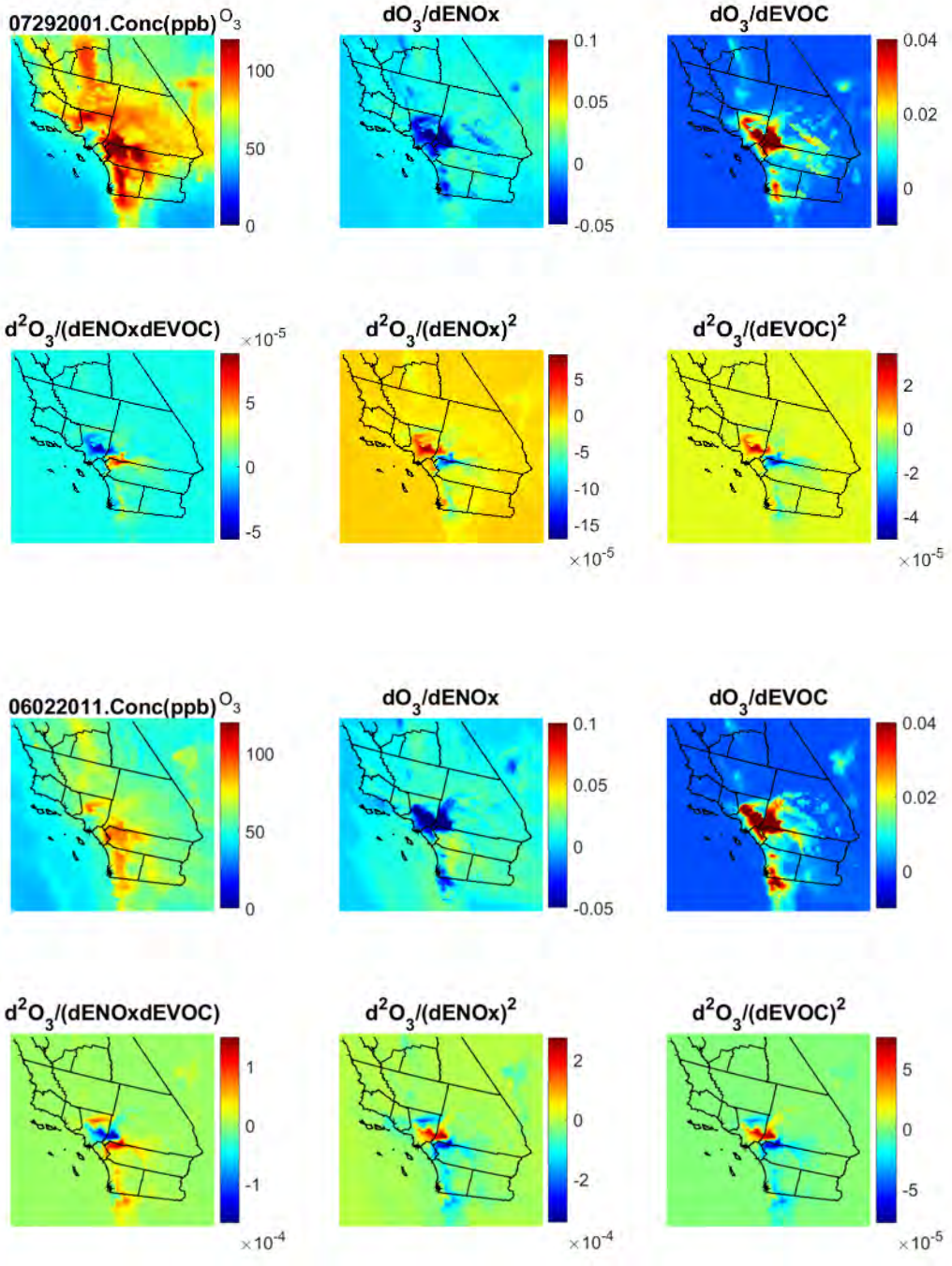

06042001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
-5
d2O3/(dENOx)2
5
0
-5
-10
×10-5
d2O3/(dEVOC)2
5
0
-5
×10-5
07202001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
2
0
-2
-4
×10-5
d2O3/(dENOx)2
×10-5
6
4
2
0
-2
-4
d2O3/(dEVOC)2
×10-5
3
2
1
0
-1

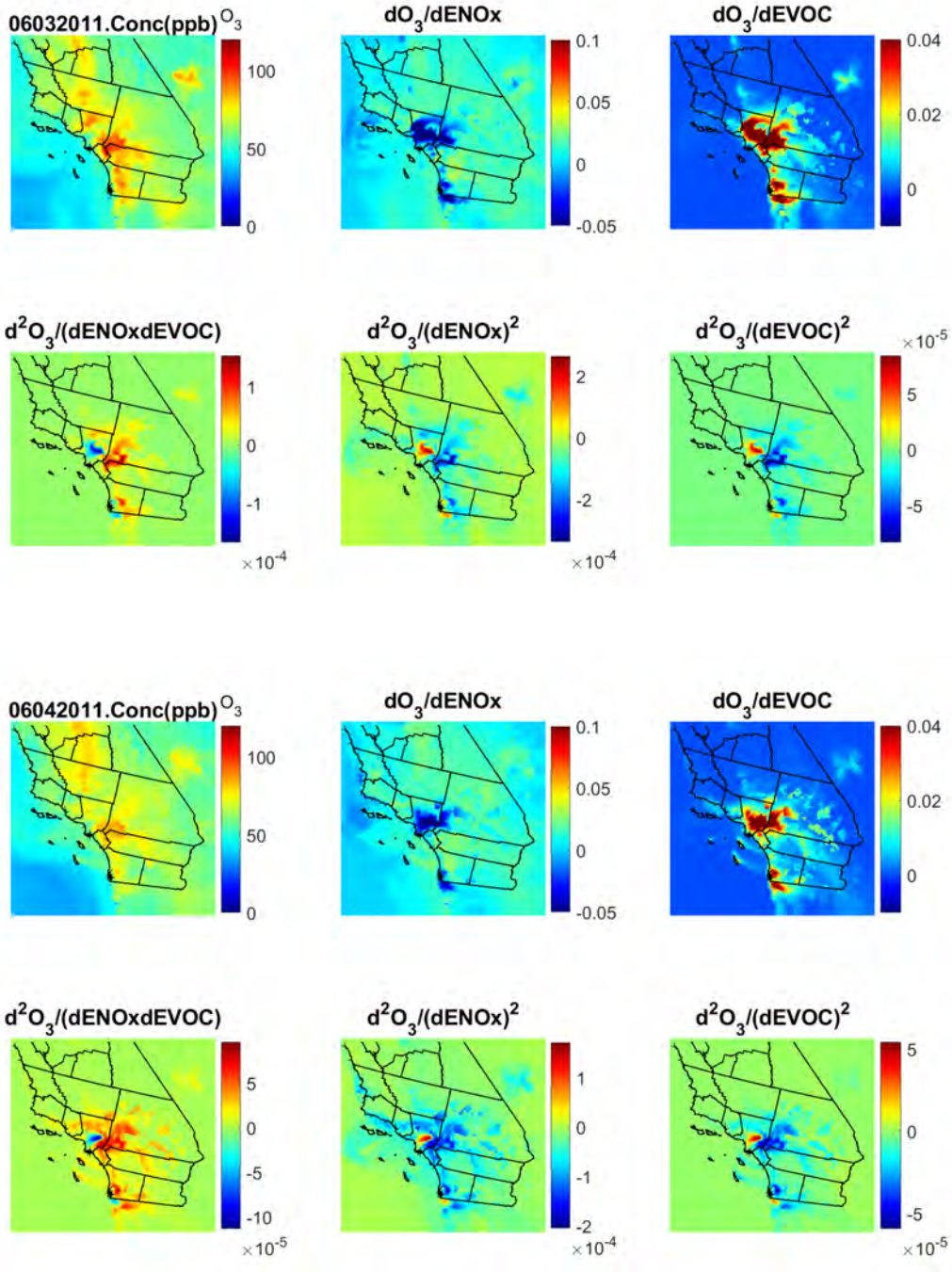

07212001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
2
0
-2
-4
×10-5
d2O3/(dENOx)2
×10-5
6
4
2
0
-2
-4
d2O3/(dEVOC)2
×10-5
3
2
1
0
-1
07222001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
4
2
0
-2
-4
-6
×10-5
d2O3/(dENOx)2
×10-5
5
0
-5
d2O3/(dEVOC)2
×10-5
4
2
0
-2

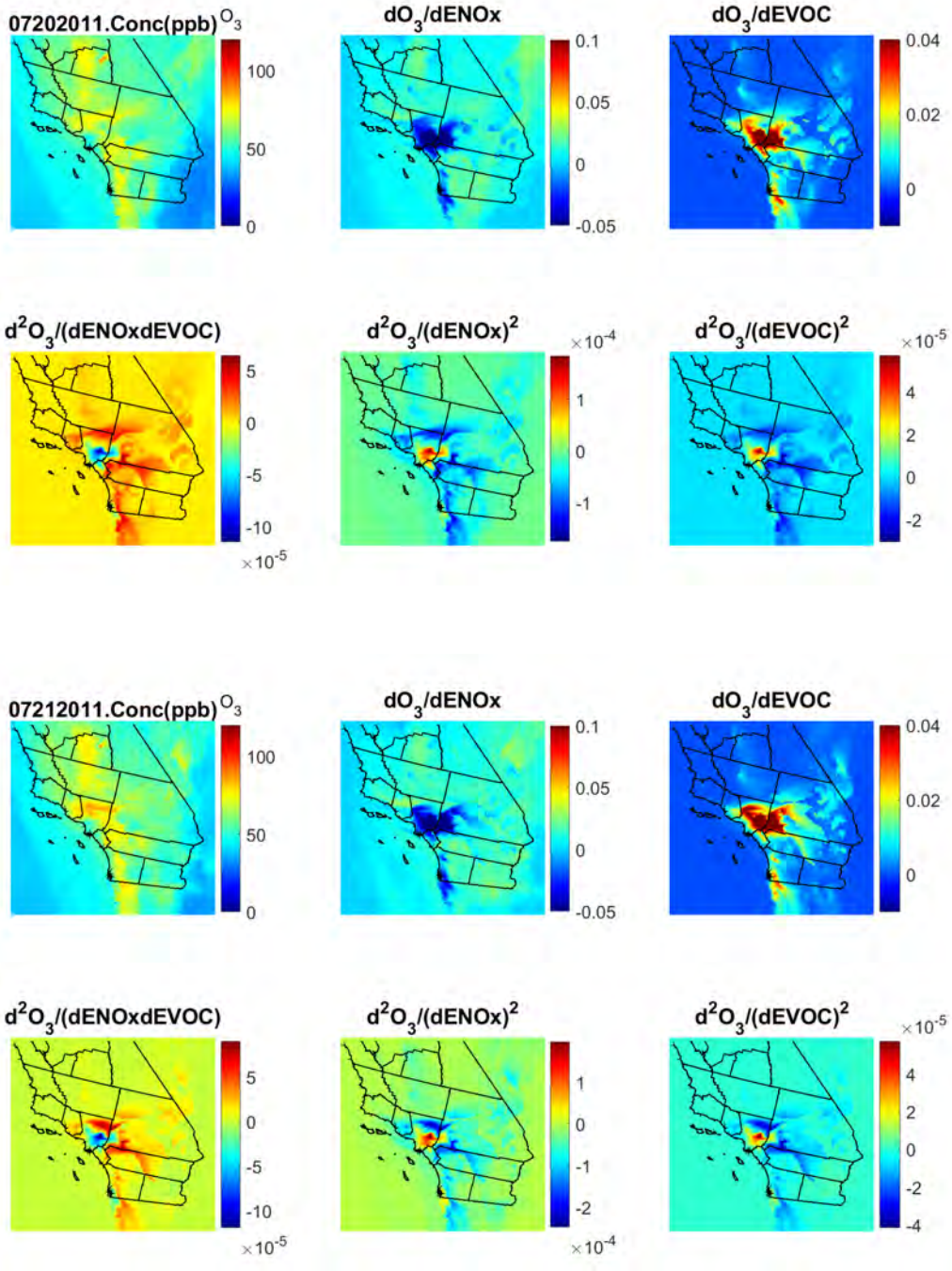

07232001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
d2O3/(dENOx)2
0
-5
-10
-15
×10-5
d2O3/(dEVOC)2
0
-5
-10
×10-5
07242001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
6
4
2
0
d2O3/(dENOx)2
2
0
-2
-4
-6
-8
×10-5
d2O3/(dEVOC)2
0
-2
-4
-6
×10-5

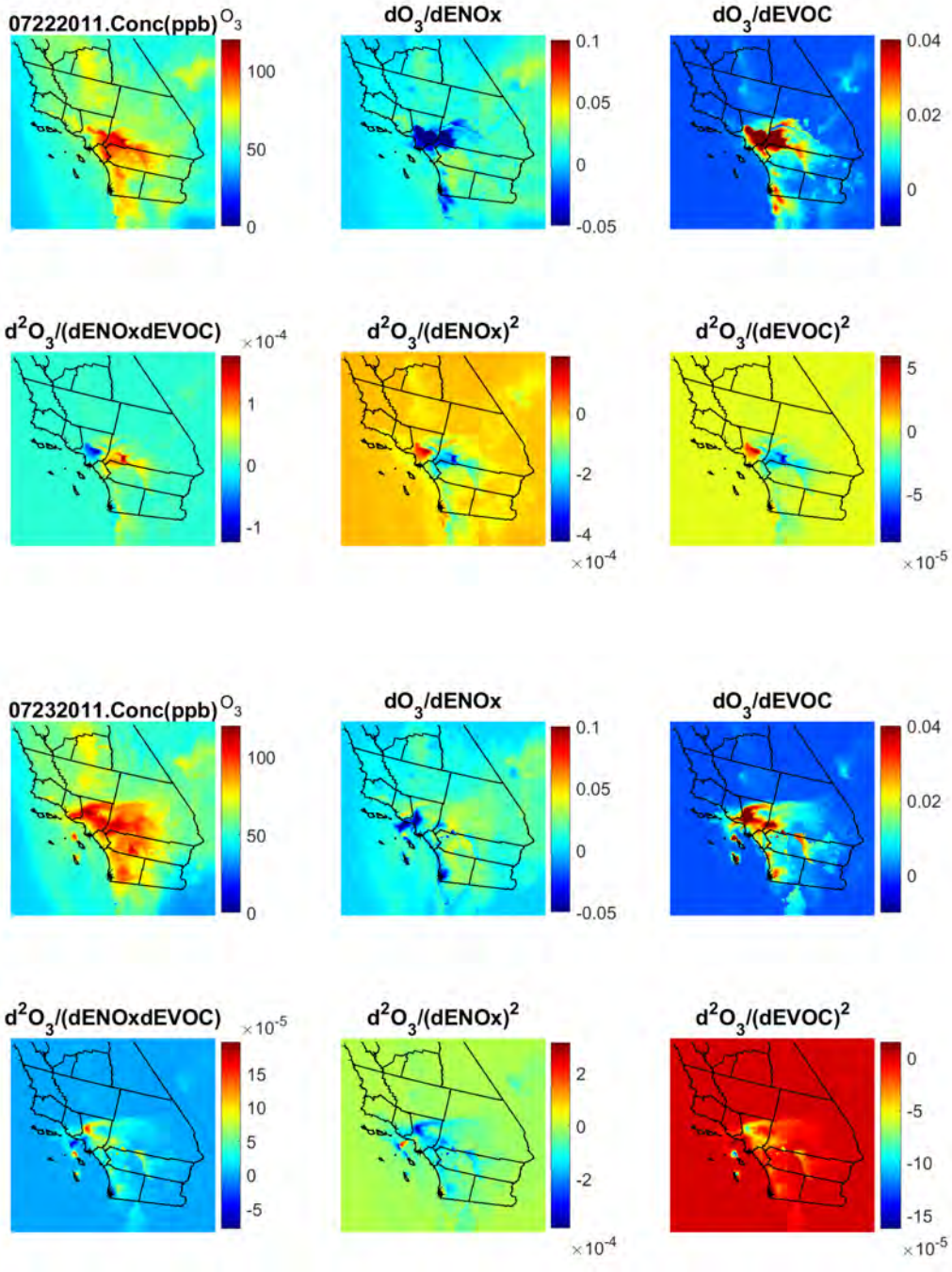

07252001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
2
0
-2
d2O3/(dENOx)2
4
2
0
-2
-4
-6
×10-5
d2O3/(dEVOC)2
1
0
-1
-2
×10-5
07262001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
4
2
0
-2
-4
×10-5
d2O3/(dENOx)2
5
0
-5
×10-5
d2O3/(dEVOC)2
×10-5
2
0
-2

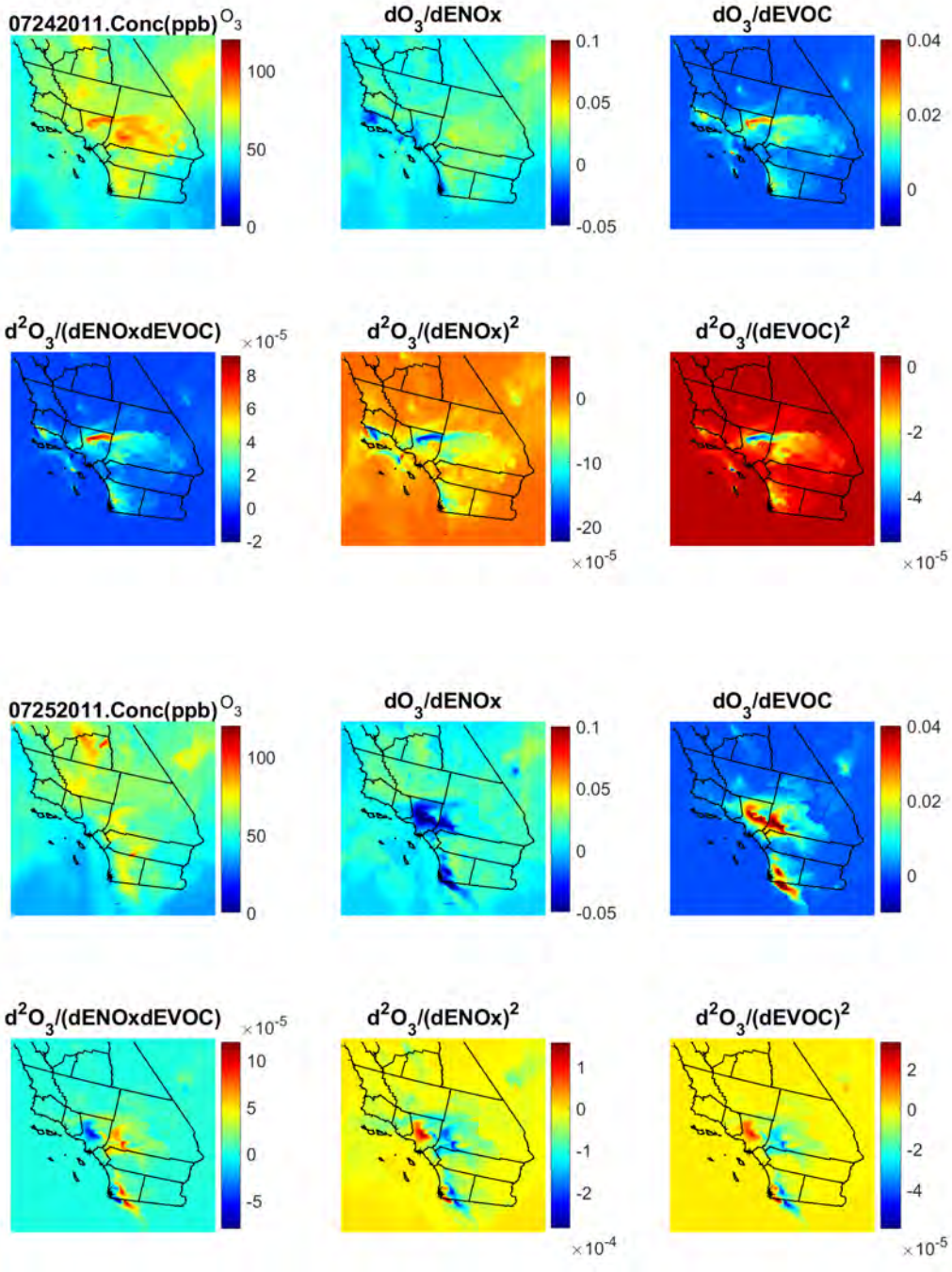

07272001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
2
0
-2
-4
×10-5
d2O3/(dENOx)2
×10-5
5
0
-5
d2O3/(dEVOC)2
×10-5
3
2
1
0
-1
07282001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
2
0
-2
-4
×10-5
d2O3/(dENOx)2
5
0
-5
×10-5
d2O3/(dEVOC)2
×10-5
3
2
1
0
-1

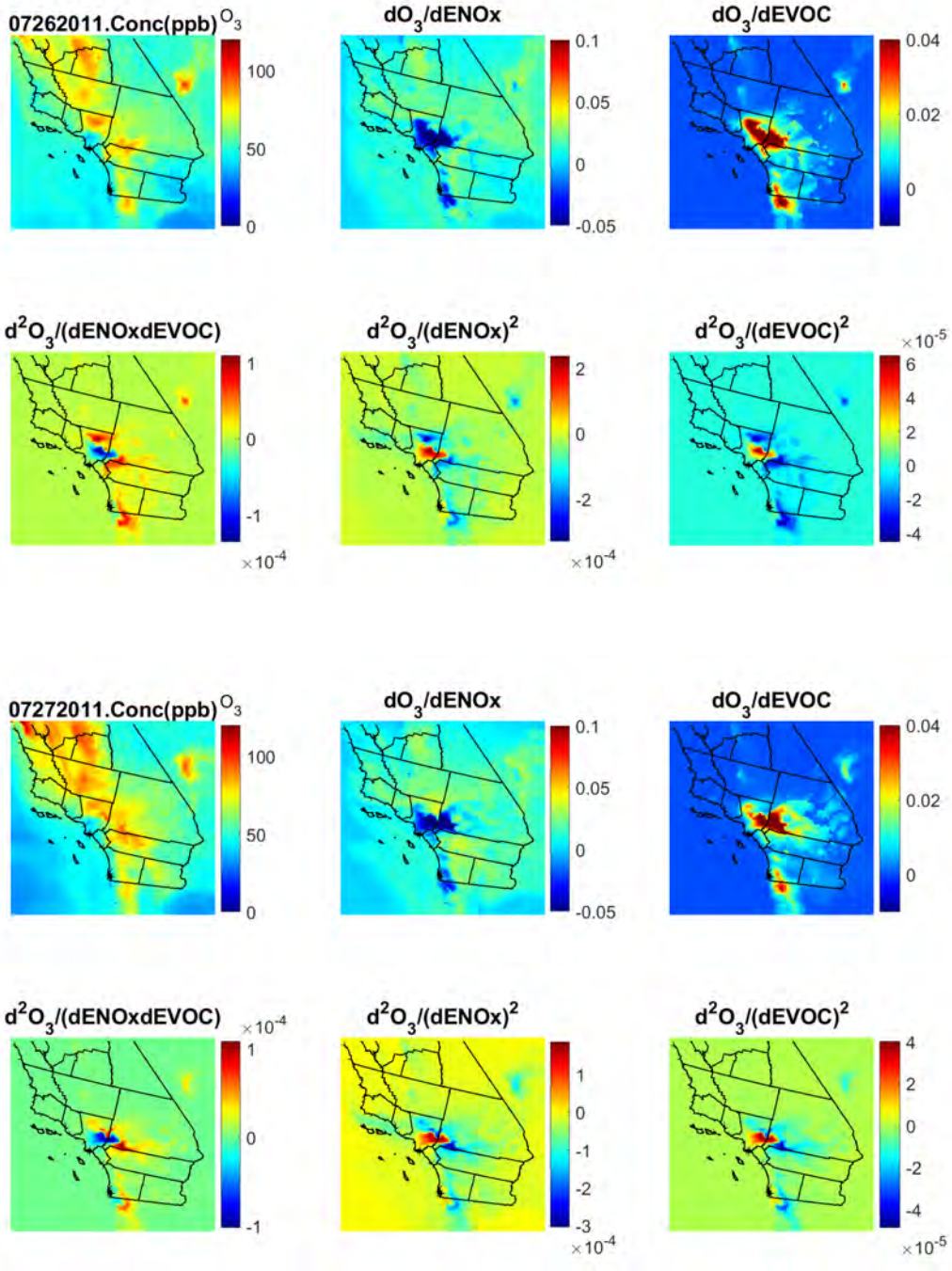

07292001.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
5
0
-5
d2O3/(dENOx)2
5
0
-5
-10
-15
×10-5
d2O3/(dEVOC)2
2
0
-2
-4
×10-5
06022011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
1
0
-1
×10-4
d2O3/(dENOx)2
2
0
-2
×10-4
d2O3/(dEVOC)2
5
0
-5
×10-5

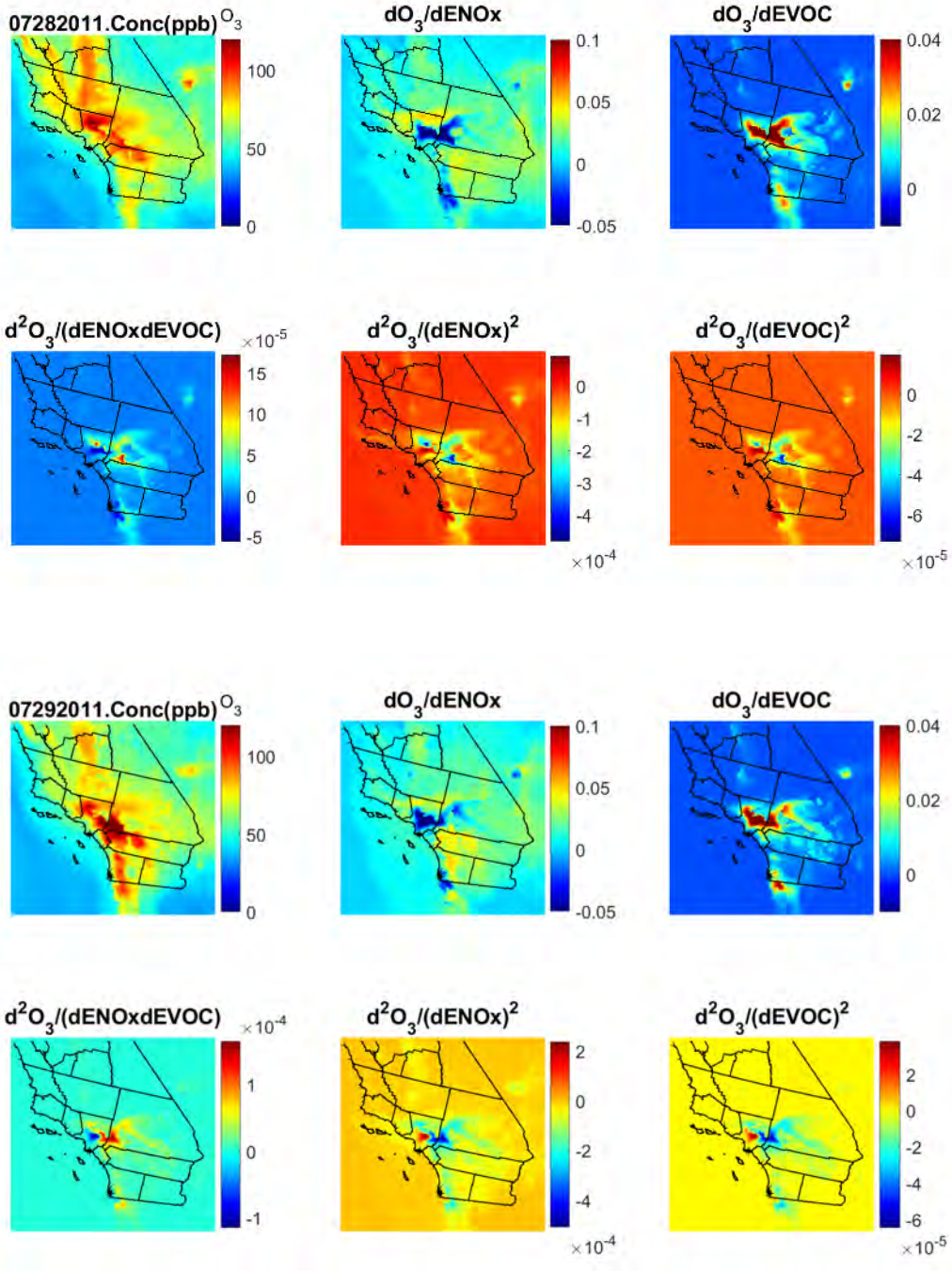

06032011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
1
0
-1
×10-4
d2O3/(dENOx)2
2
0
-2
×10-4
d2O3/(dEVOC)2
×10-5
5
0
-5
06042011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
5
0
-5
-10
×10-5
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
5
0
-5
×10-5

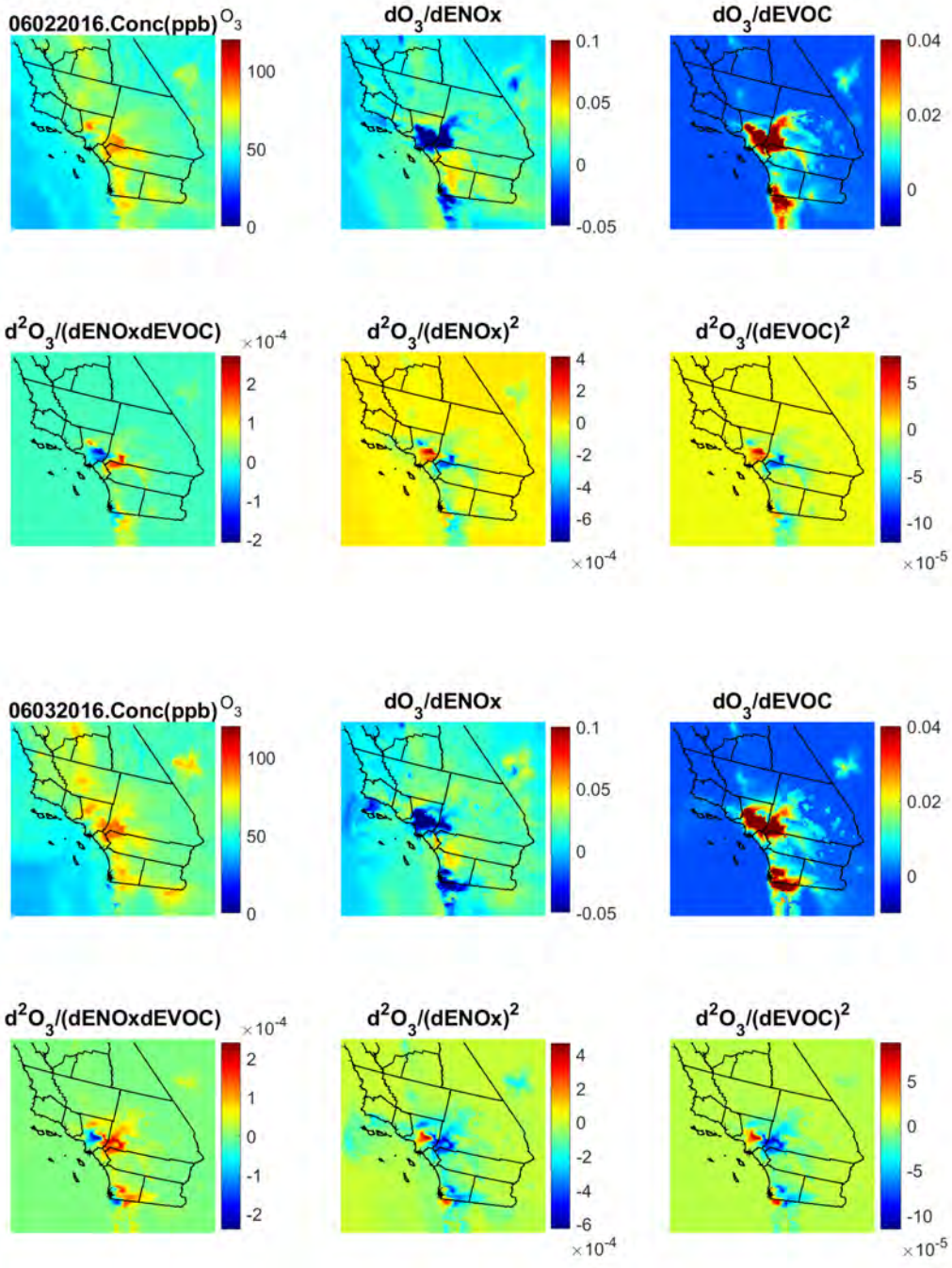

07202011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
5
0
-5
-10
×10-5
d2O3/(dENOx)2
×10-4
1
0
-1
d2O3/(dEVOC)2
×10-5
4
2
0
-2
07212011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
5
0
-5
-10
×10-5
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
×10-5
4
2
0
-2
-4

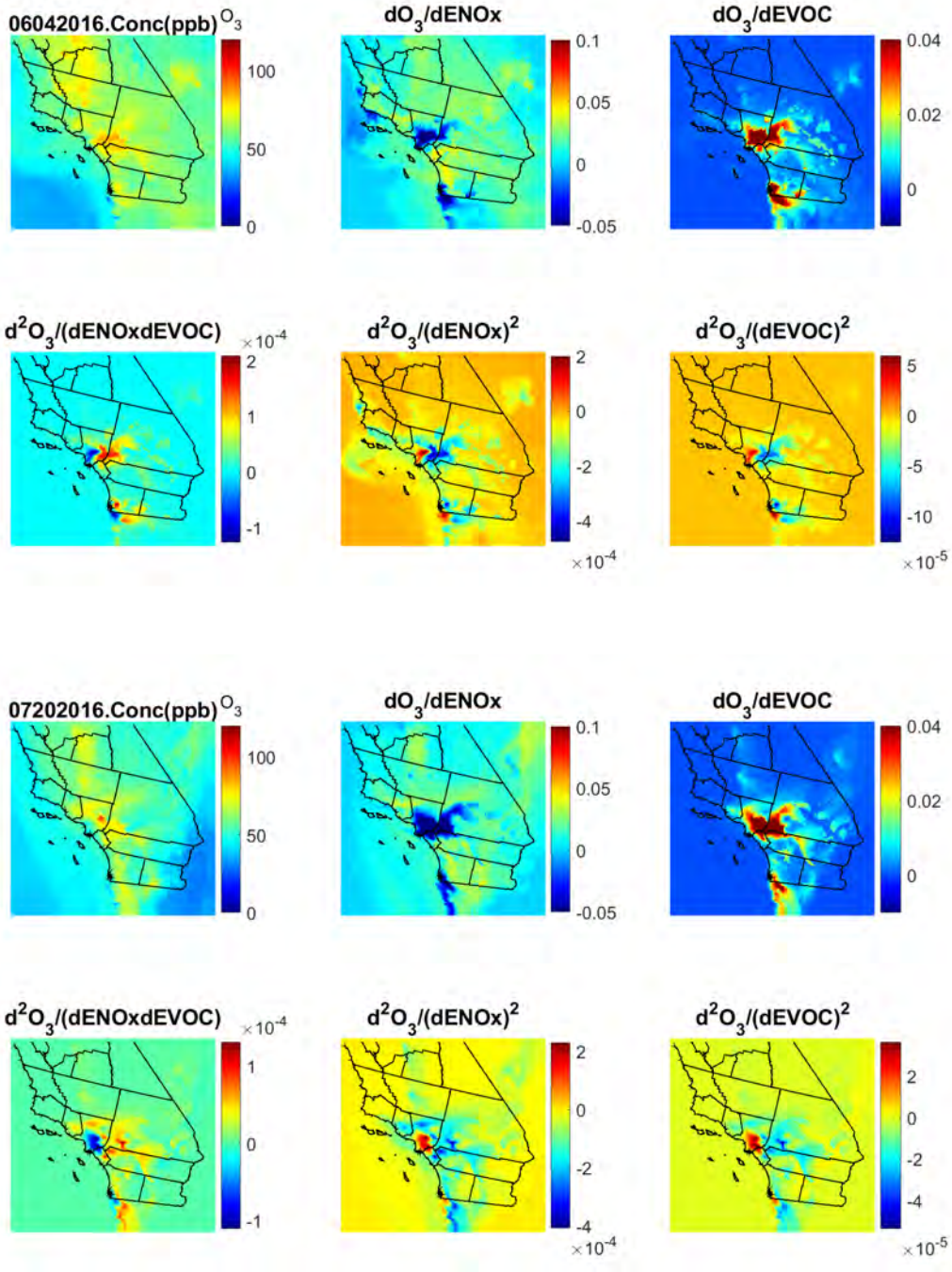

07222011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
1
0
-1
d2O3/(dENOx)2
0
-2
-4
×10-4
d2O3/(dEVOC)2
5
0
-5
×10-5
07232011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
15
10
5
0
-5
d2O3/(dENOx)2
2
0
-2
×10-4
d2O3/(dEVOC)2
0
-5
-10
-15
×10-5

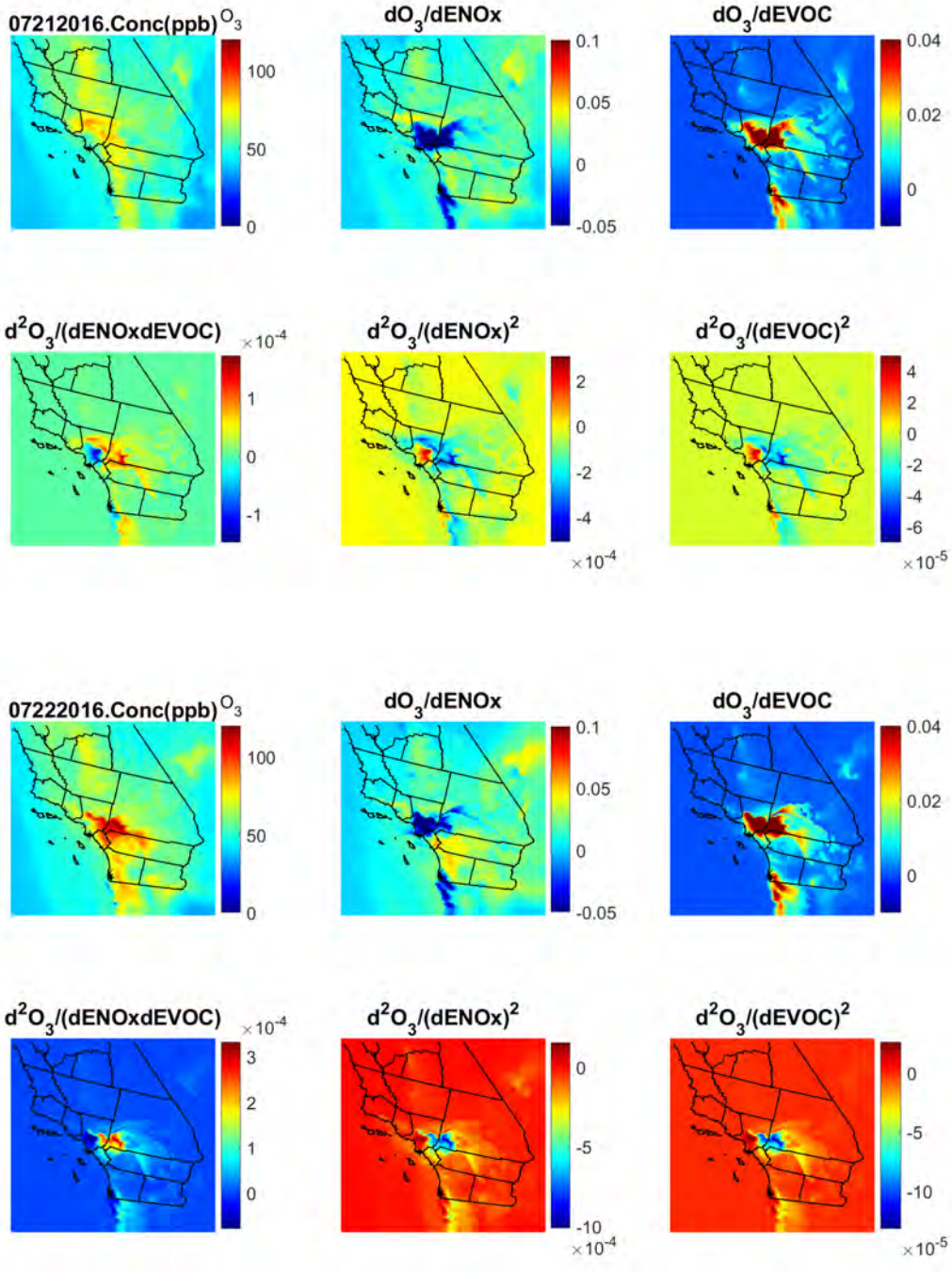

07242011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
8
6
4
2
0
-2
d2O3/(dENOx)2
0
-10
-20
×10-5
d2O3/(dEVOC)2
0
-2
-4
×10-5
07252011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
-5
d2O3/(dENOx)2
1
0
-1
-2
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
×10-5

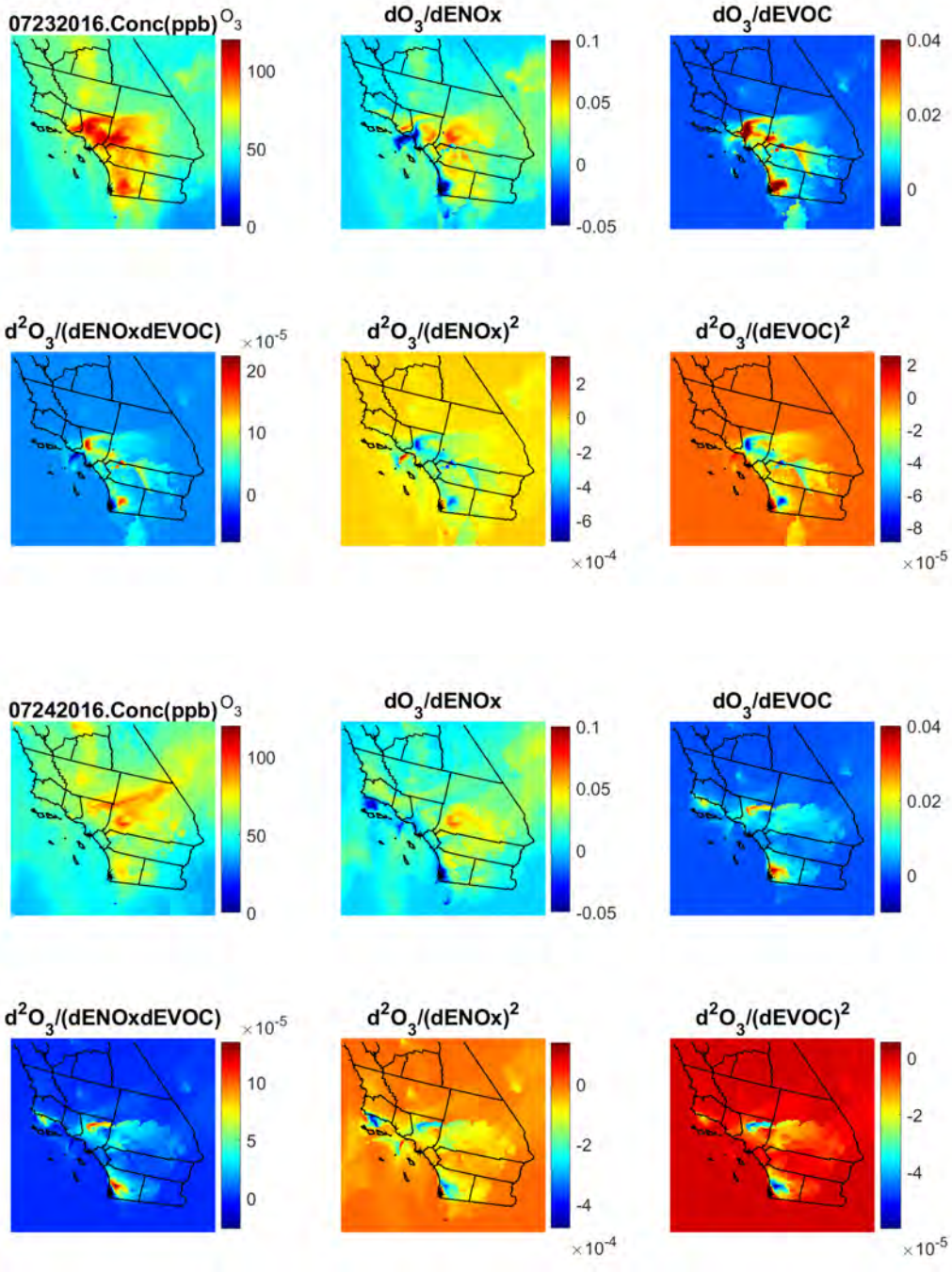

07262011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
1
0
-1
×10-4
d2O3/(dENOx)2
2
0
-2
×10-4
d2O3/(dEVOC)2
×10-5
6
4
2
0
-2
-4
07272011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
1
0
-1
d2O3/(dENOx)2
1
0
-1
-2
-3
×10-4
d2O3/(dEVOC)2
4
2
0
-2
-4
×10-5

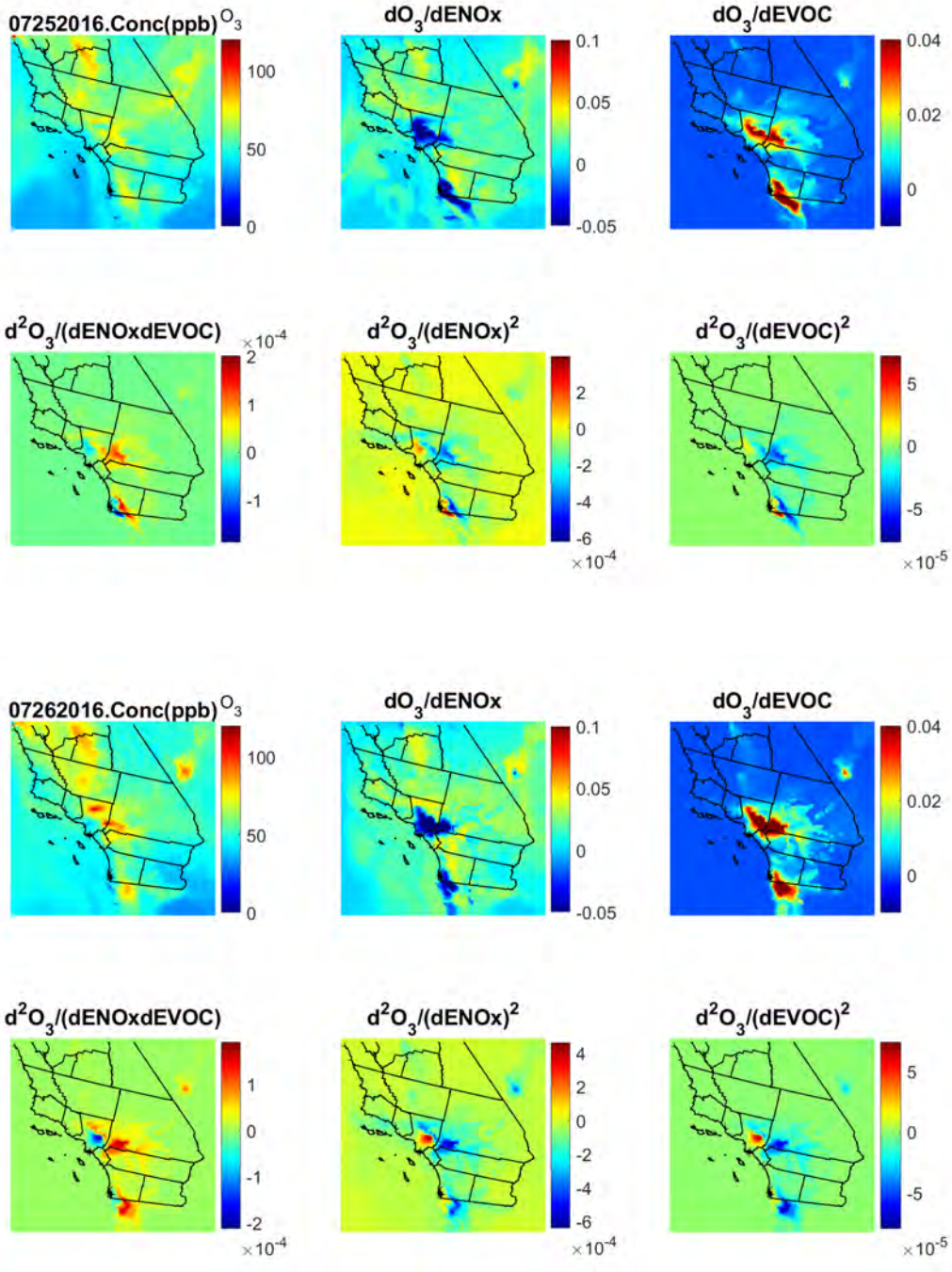

07282011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
15
10
5
0
-5
d2O3/(dENOx)2
0
-1
-2
-3
-4
×10-4
d2O3/(dEVOC)2
0
-2
-4
-6
×10-5
07292011.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
1
0
-1
d2O3/(dENOx)2
2
0
-2
-4
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
-6
×10-5

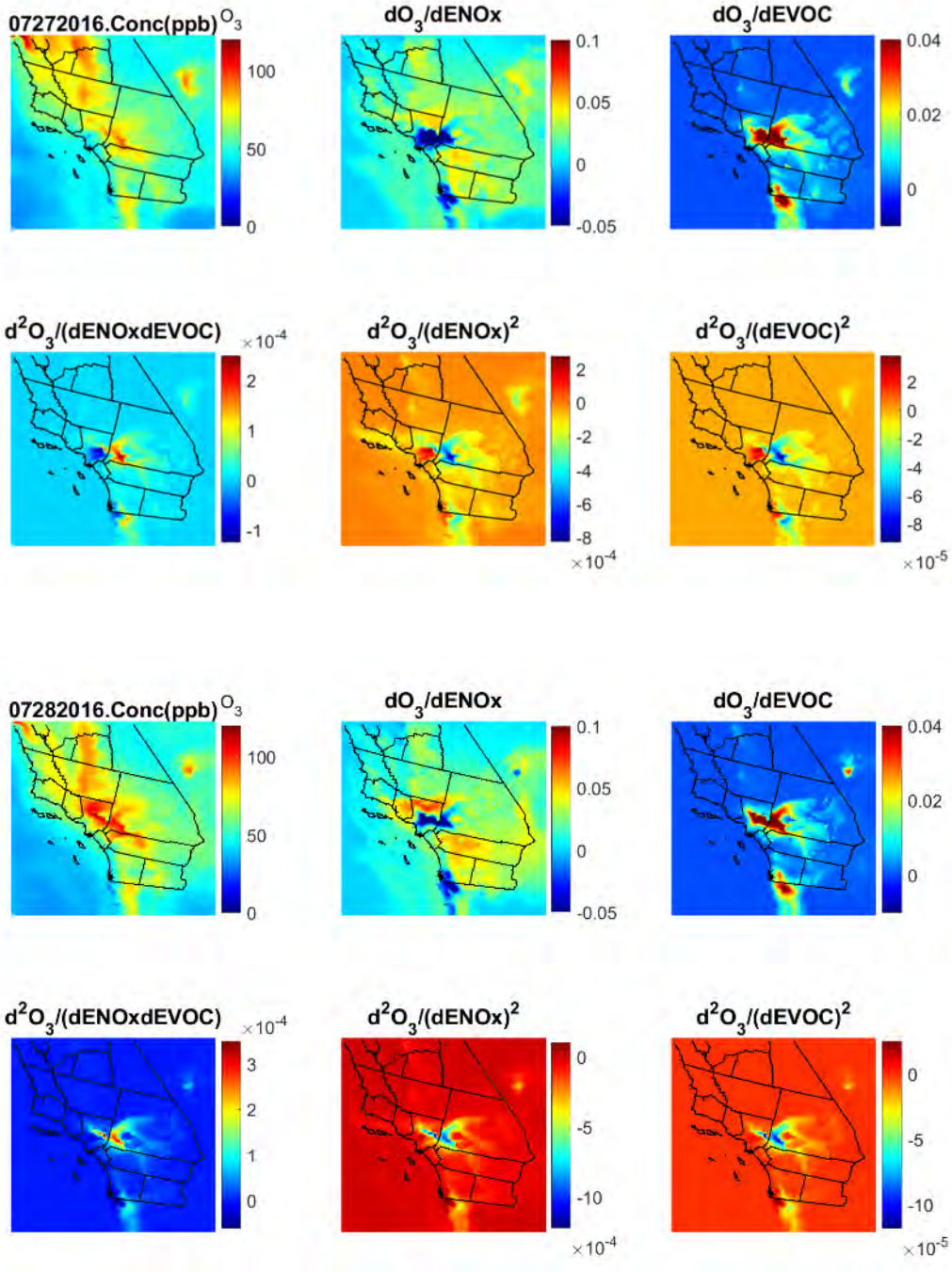

06022016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
1
0
-1
-2
d2O3/(dENOx)2
4
2
0
-2
-4
-6
×10-4
d2O3/(dEVOC)2
5
0
-5
-10
×10-5
06032016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
1
0
-1
-2
d2O3/(dENOx)2
4
2
0
-2
-4
-6
×10-4
d2O3/(dEVOC)2
5
0
-5
-10
×10-5

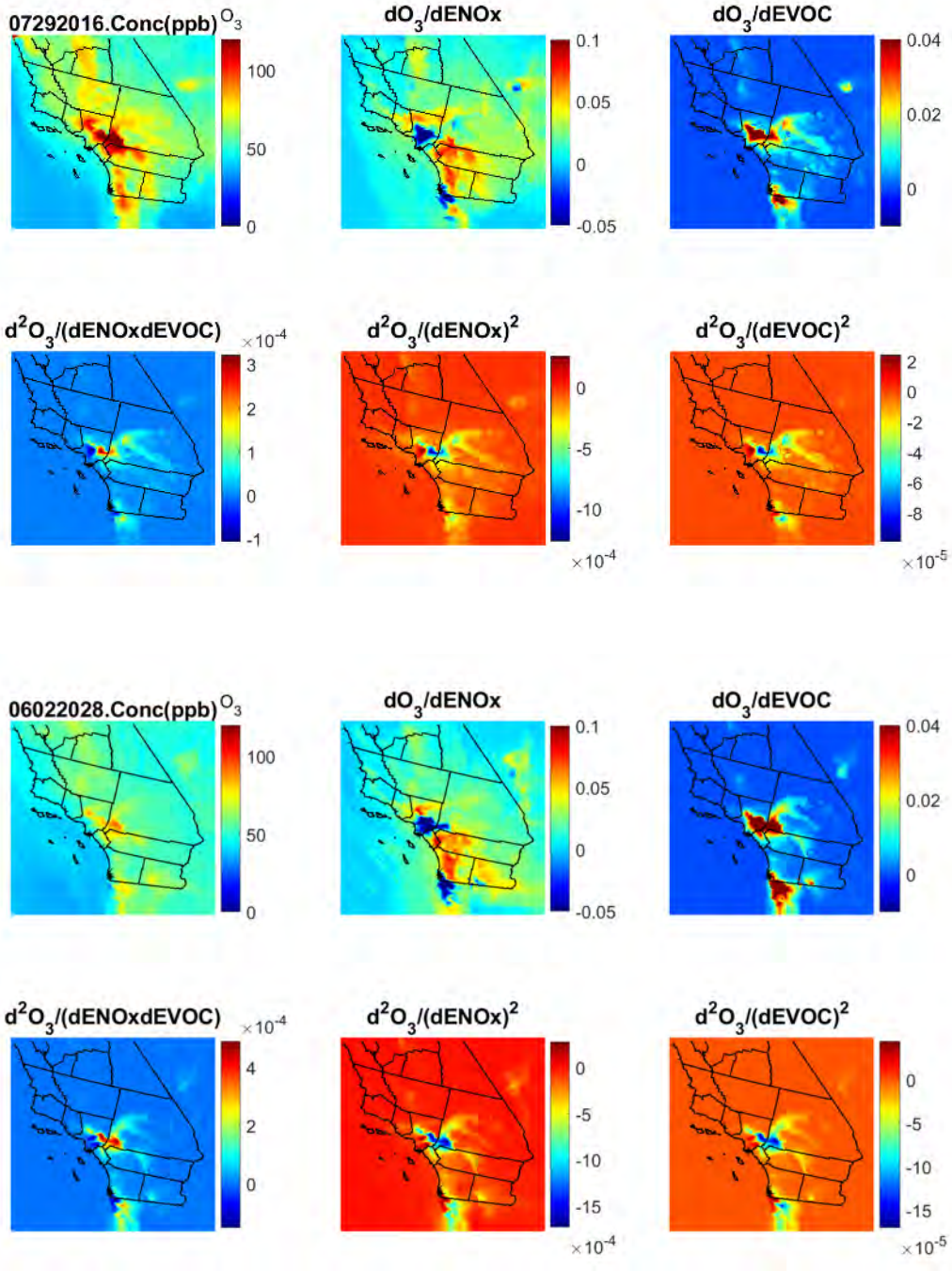

06042016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
1
0
-1
d2O3/(dENOx)2
2
0
-2
-4
×10-4
d2O3/(dEVOC)2
5
0
-5
-10
×10-5
07202016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
1
0
-1
d2O3/(dENOx)2
2
0
-2
-4
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
×10-5

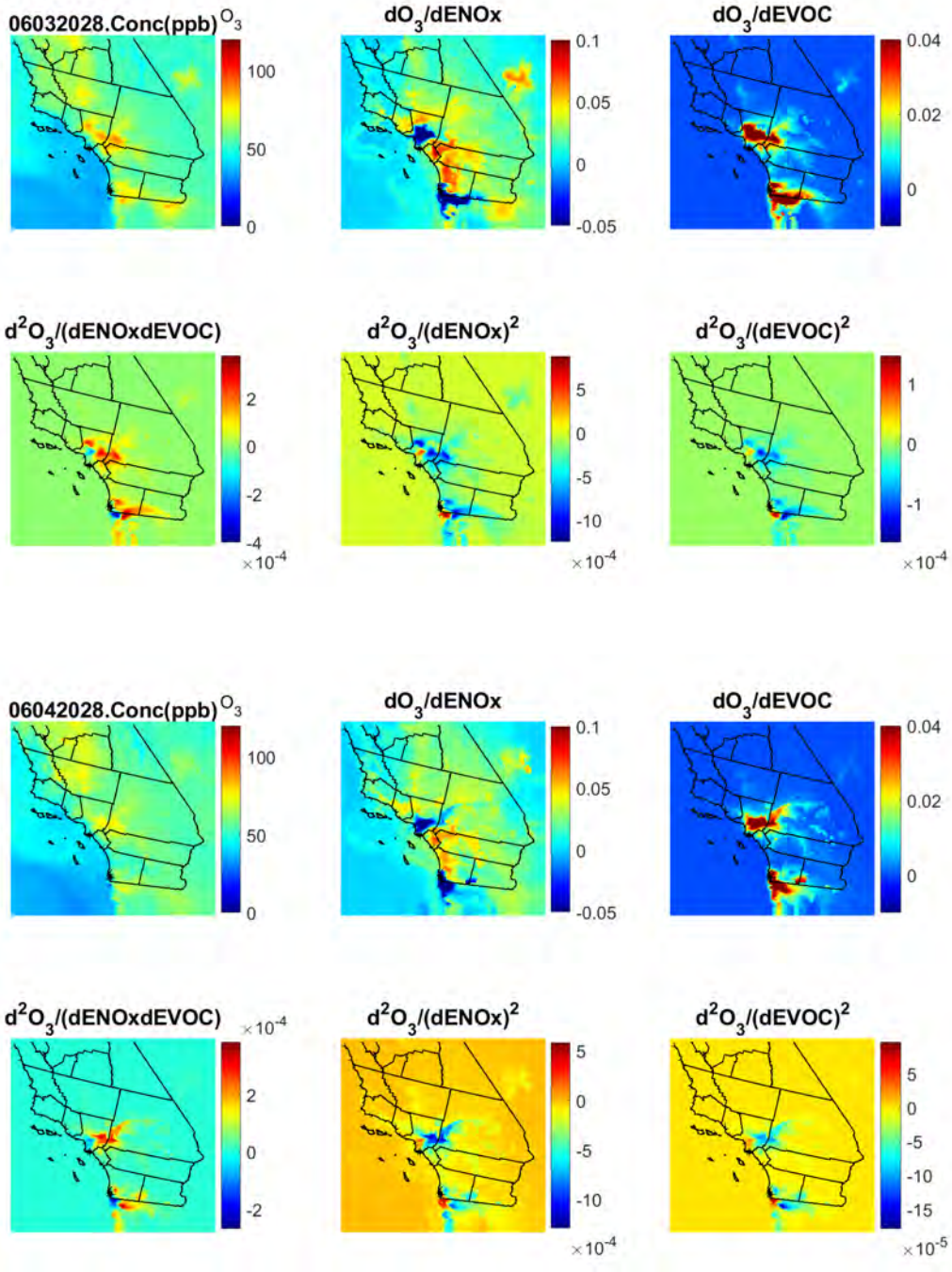

07212016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
1
0
-1
d2O3/(dENOx)2
2
0
-2
-4
×10-4
d2O3/(dEVOC)2
4
2
0
-2
-4
-6
×10-5
07222016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5

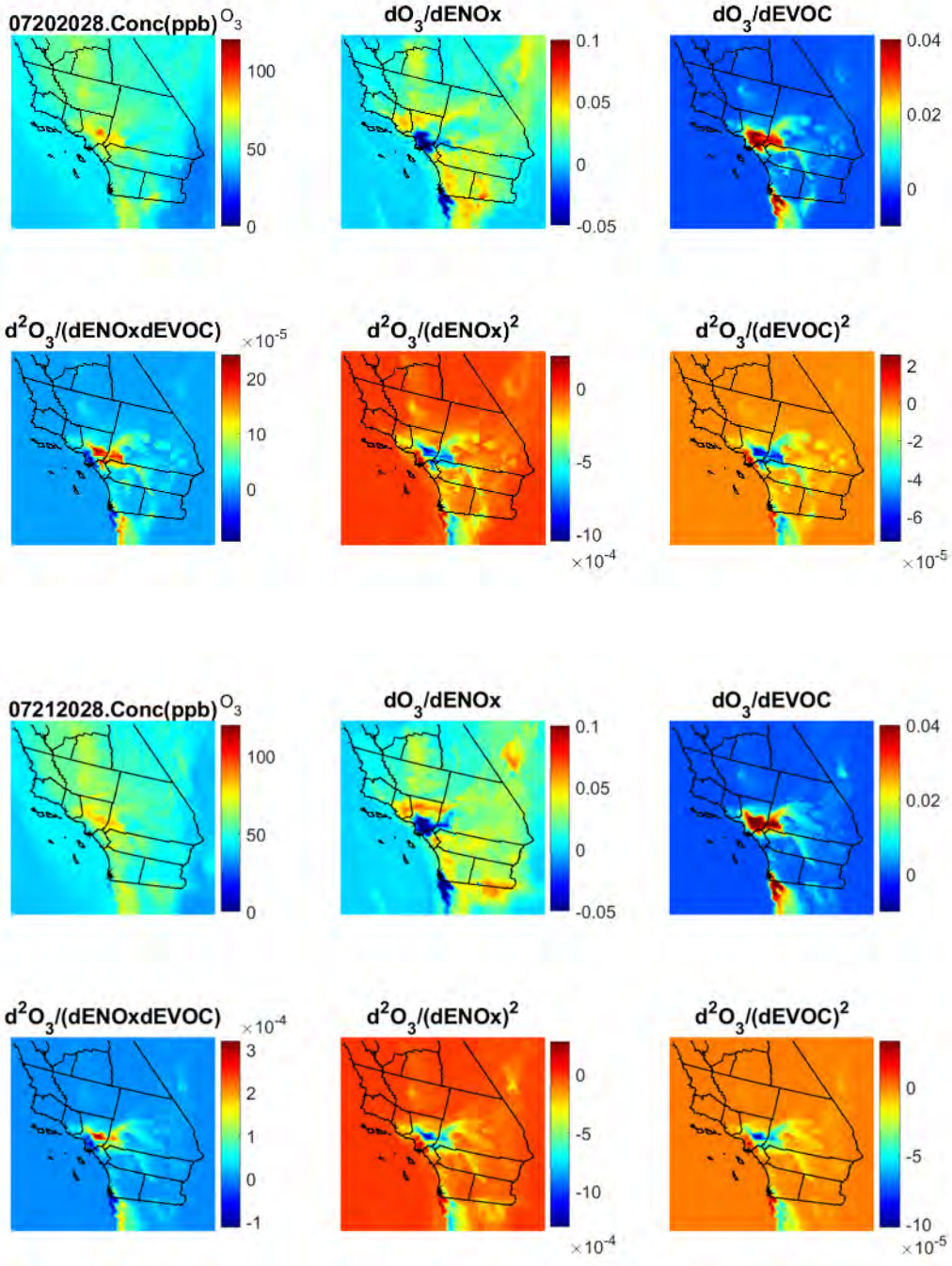

07232016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
20
10
0
d2O3/(dENOx)2
2
0
-2
-4
-6
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
-6
-8
×10-5
07242016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
10
5
0
d2O3/(dENOx)2
0
-2
-4
×10-4
d2O3/(dEVOC)2
0
-2
-4
×10-5

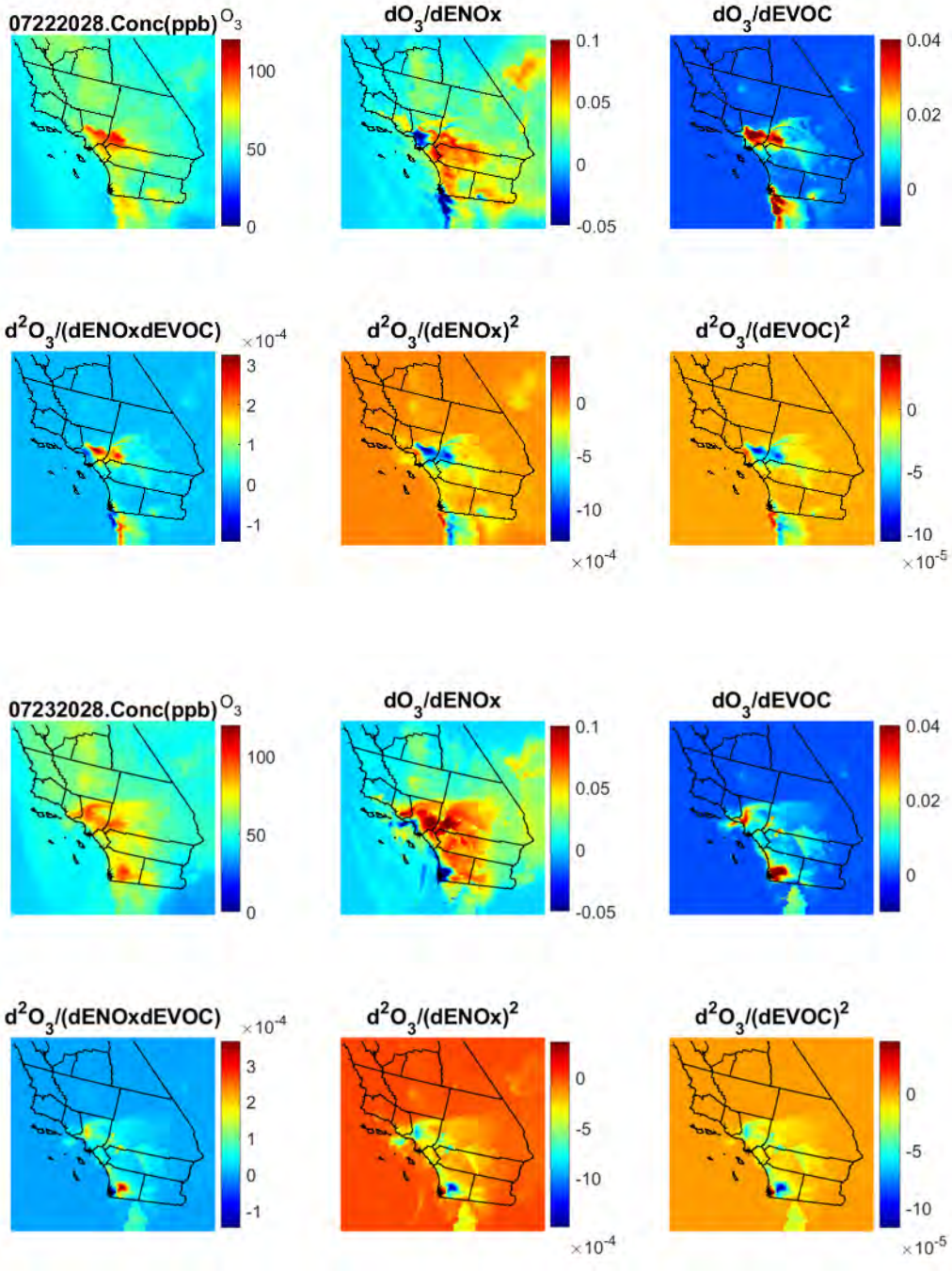

07252016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
1
0
-1
d2O3/(dENOx)2
2
0
-2
-4
-6
×10-4
d2O3/(dEVOC)2
5
0
-5
×10-5
07262016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
1
0
-1
-2
×10-4
d2O3/(dENOx)2
4
2
0
-2
-4
-6
×10-4
d2O3/(dEVOC)2
5
0
-5
×10-5

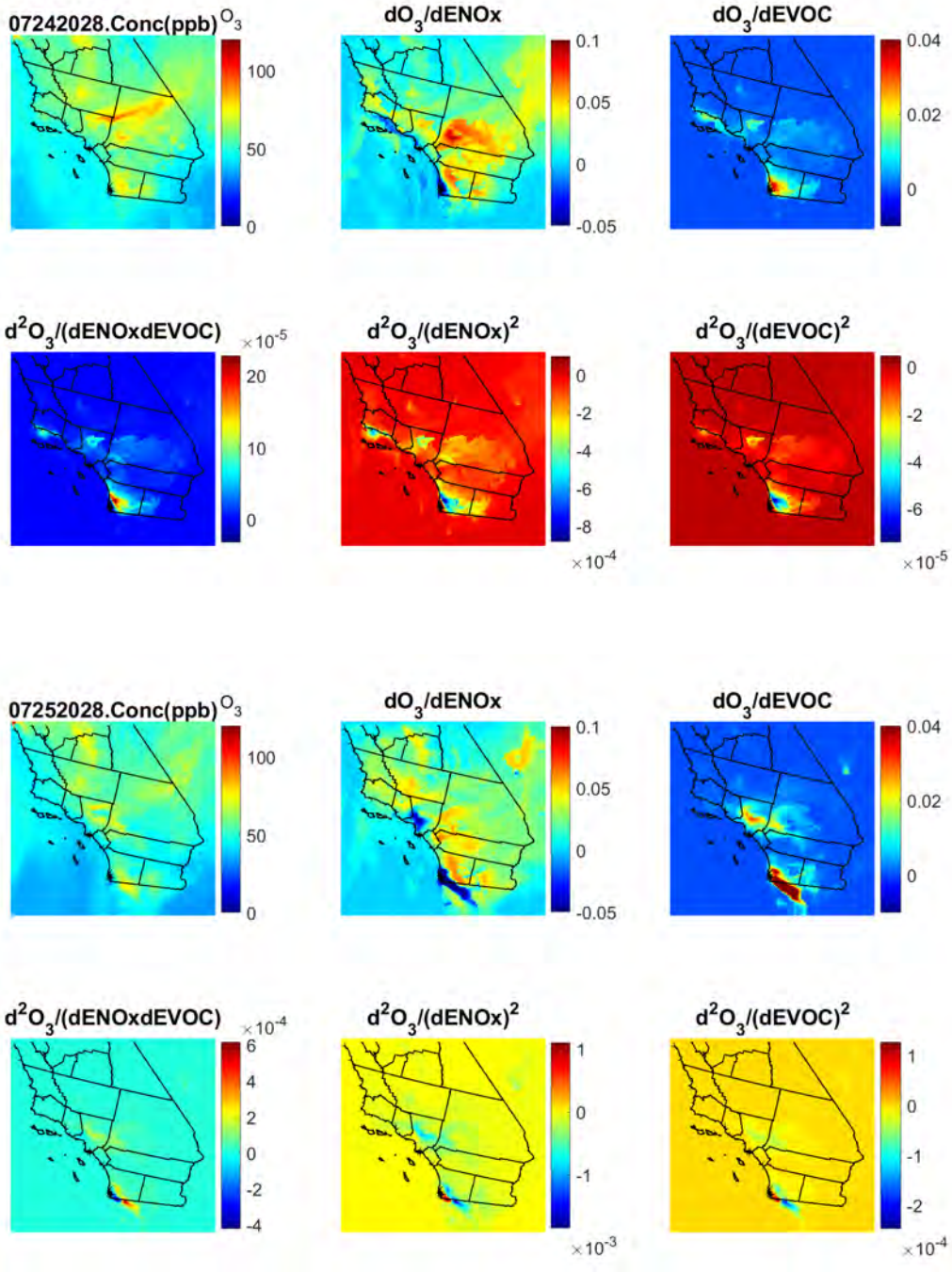

07272016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
1
0
-1
d2O3/(dENOx)2
2
0
-2
-4
-6
-8
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
-6
-8
×10-5
07282016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5

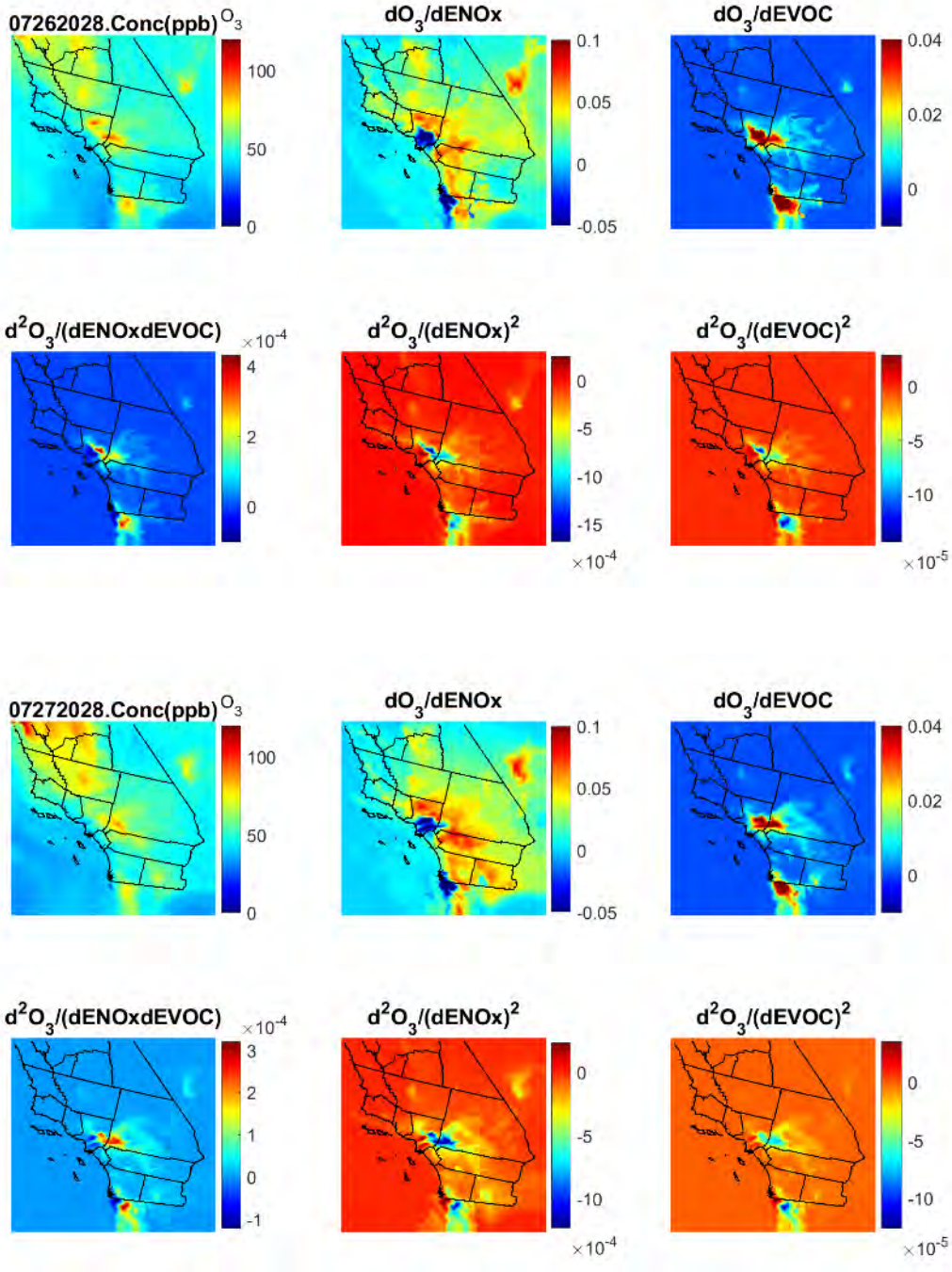

07292016.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
-6
-8
×10-5
06022028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
4
2
0
d2O3/(dENOx)2
0
-5
-10
-15
×10-4
d2O3/(dEVOC)2
0
-5
-10
-15
×10-5

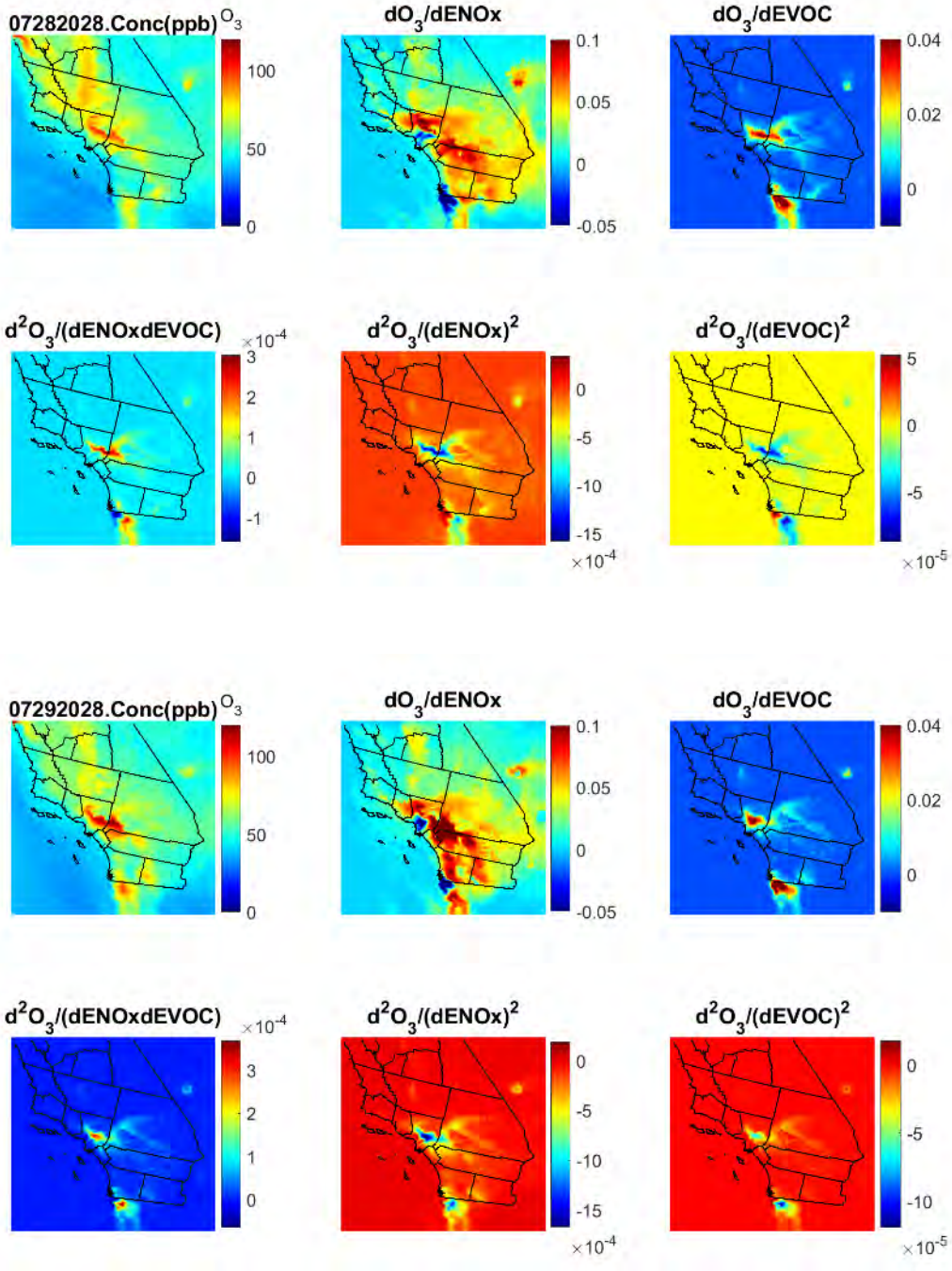

06032028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
2
0
-2
-4
×10-4
d2O3/(dENOx)2
5
0
-5
-10
×10-4
d2O3/(dEVOC)2
1
0
-1
×10-4
06042028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
0
-2
d2O3/(dENOx)2
5
0
-5
-10
×10-4
d2O3/(dEVOC)2
5
0
-5
-10
-15
×10-5

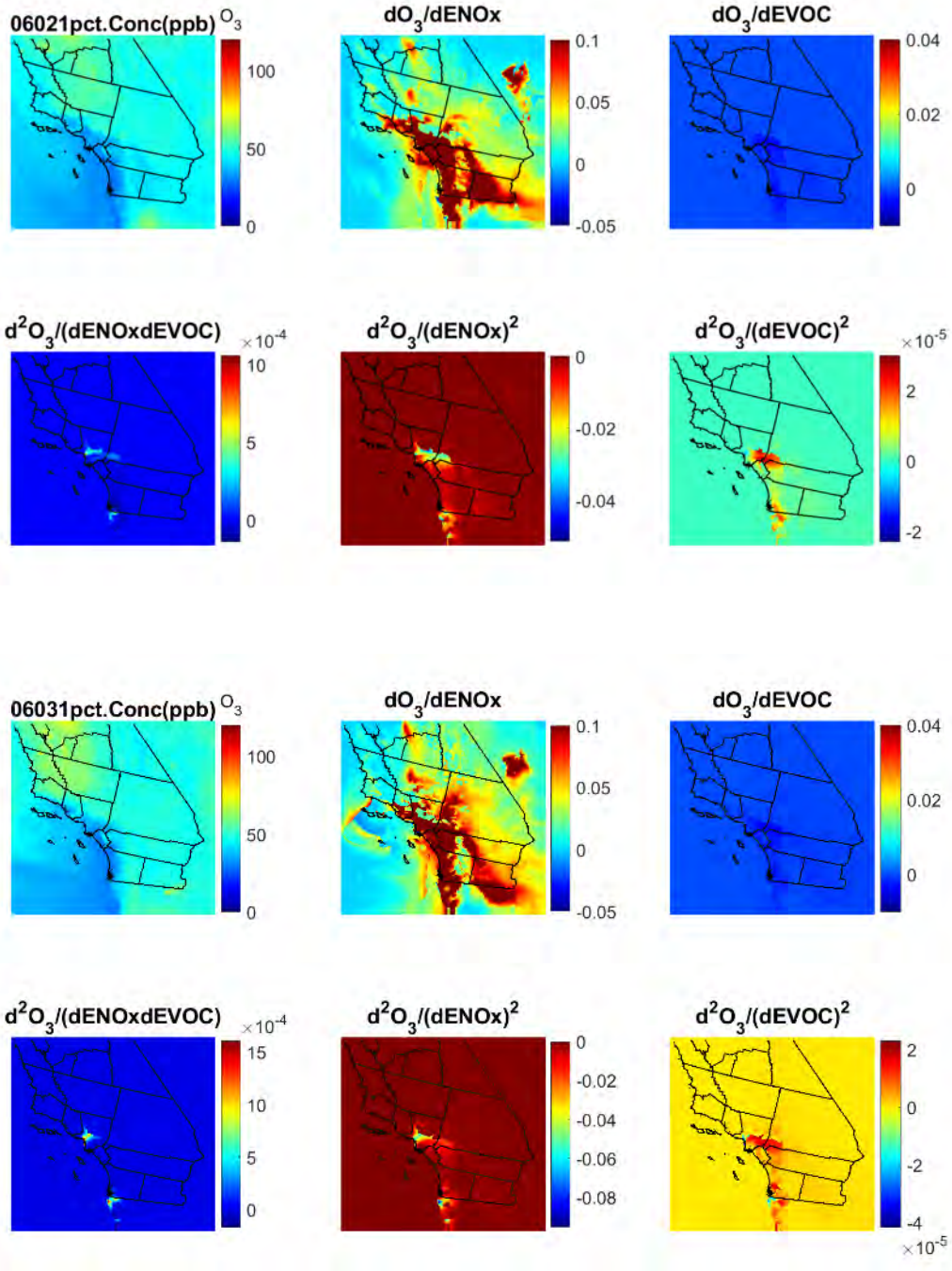

07202028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
20
10
0
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
2
0
-2
-4
-6
×10-5
07212028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5

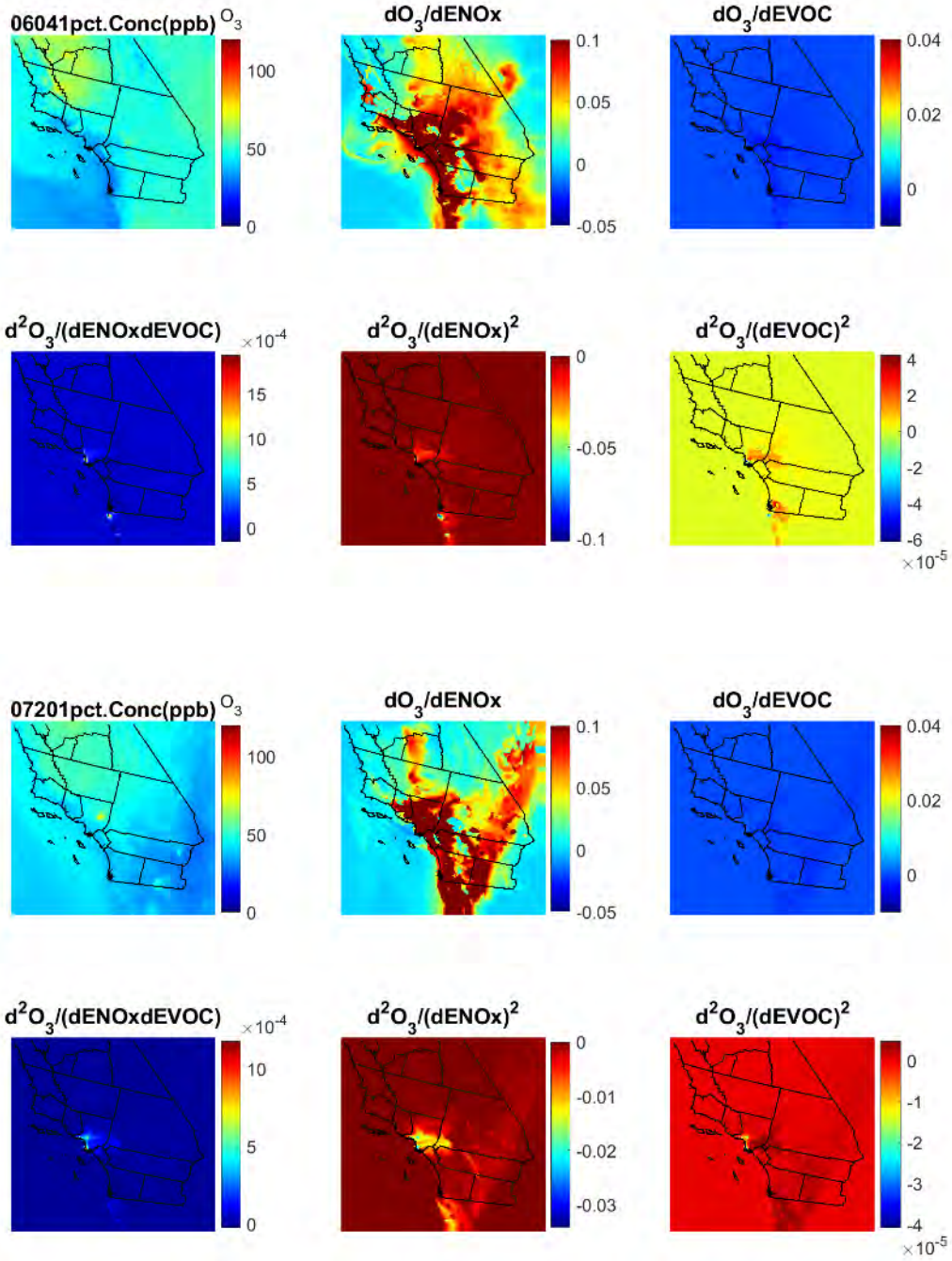

07222028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5
07232028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5

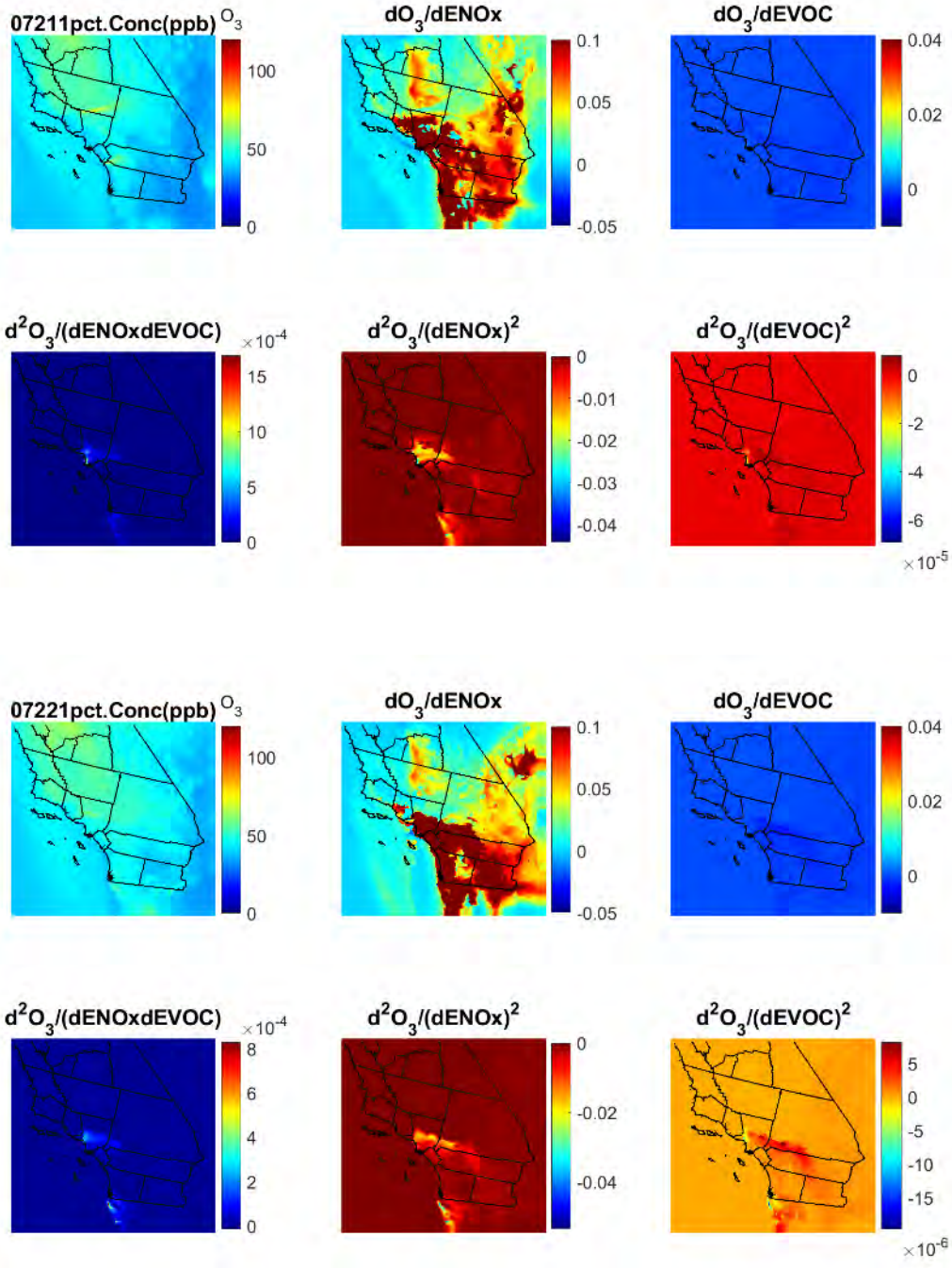

07242028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
20
10
0
d2O3/(dENOx)2
0
-2
-4
-6
-8
×10-4
d2O3/(dEVOC)2
0
-2
-4
-6
×10-5
07252028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
6
4
2
0
-2
-4
d2O3/(dENOx)2
1
0
-1
×10-3
d2O3/(dEVOC)2
1
0
-1
-2
×10-4

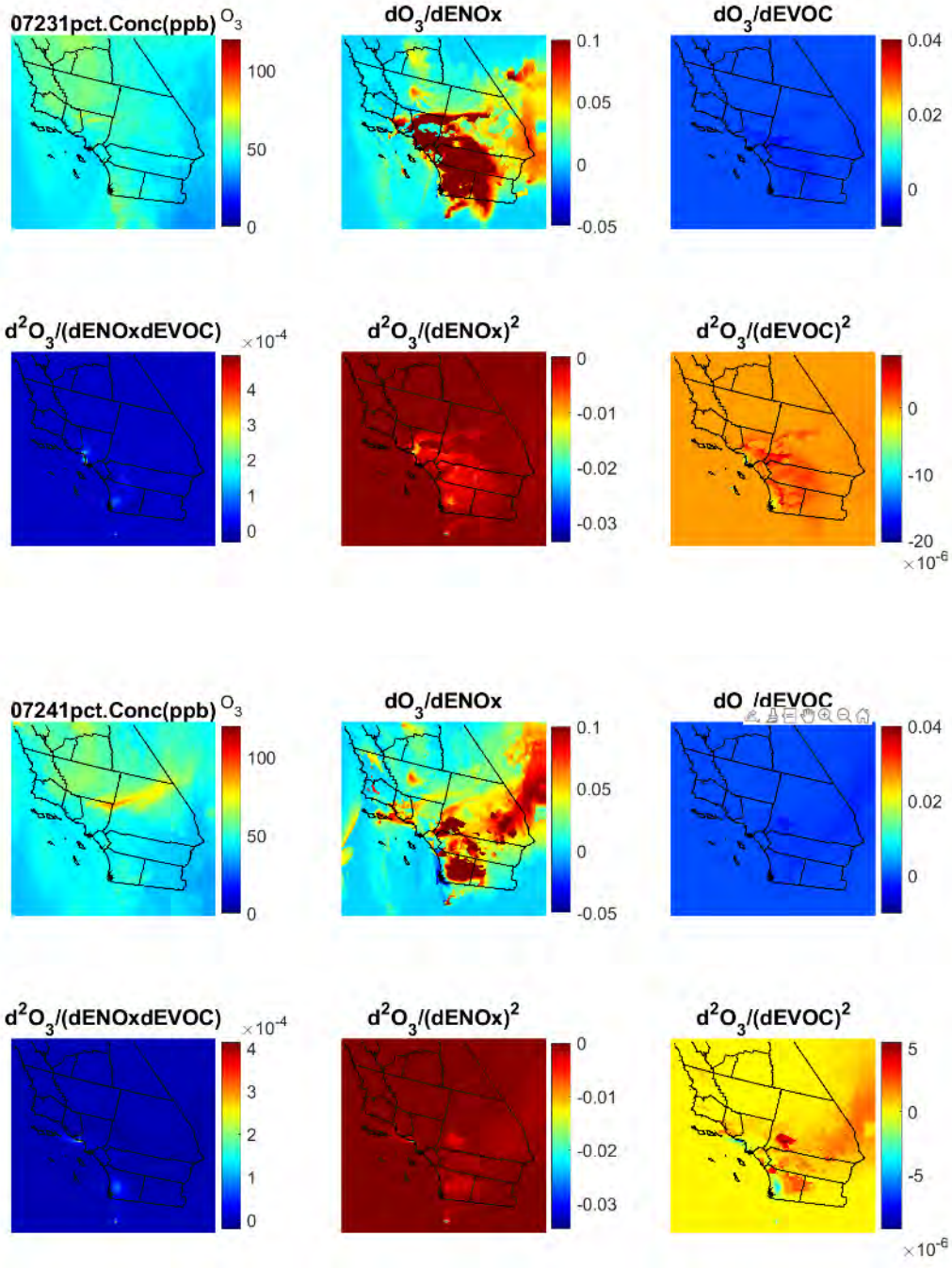

07262028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
4
2
0
d2O3/(dENOx)2
0
-5
-10
-15
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5
07272028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-5
-10
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5

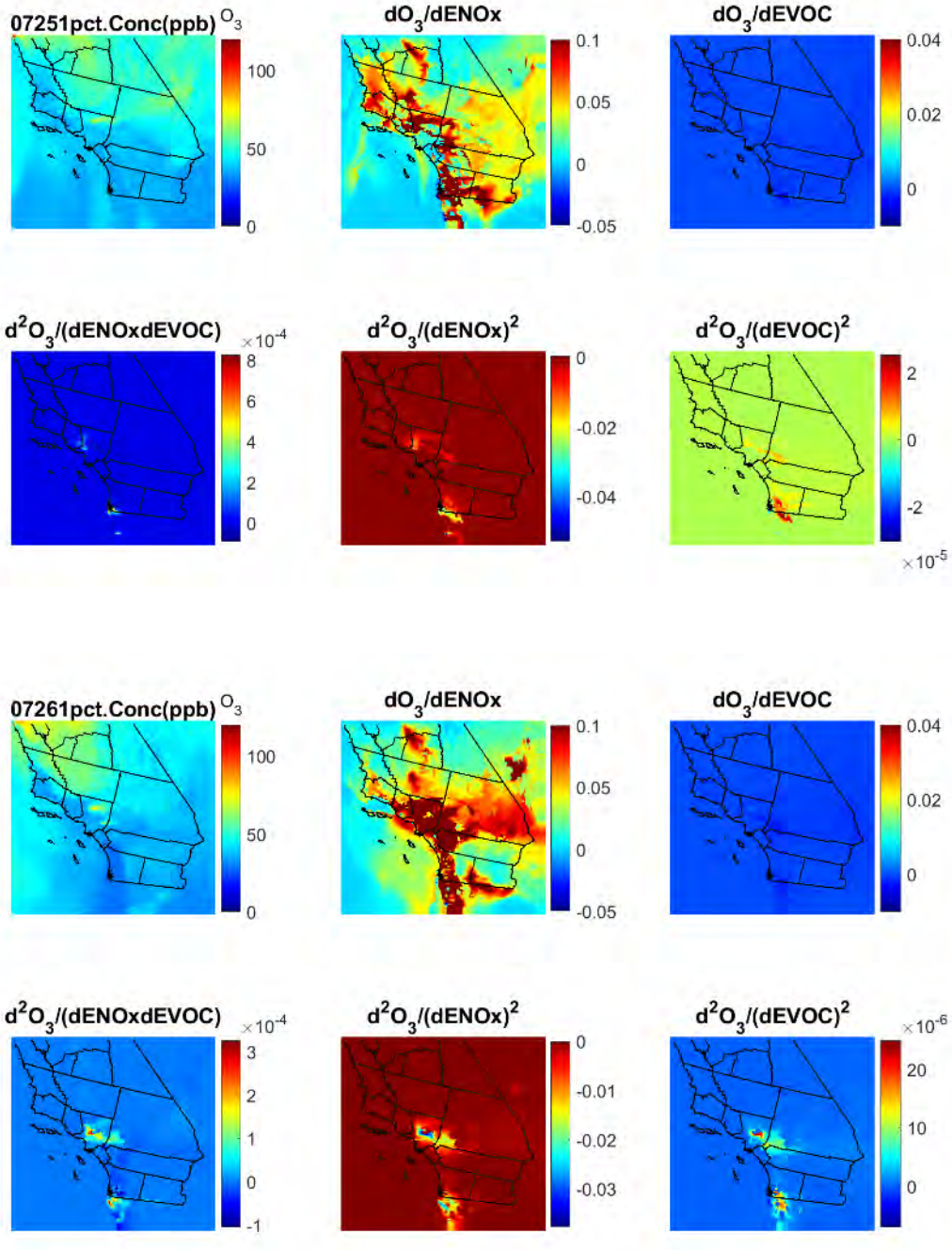

07282028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-5
-10
-15
×10-4
d2O3/(dEVOC)2
5
0
-5
×10-5
07292028.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
d2O3/(dENOx)2
0
-5
-10
-15
×10-4
d2O3/(dEVOC)2
0
-5
-10
×10-5

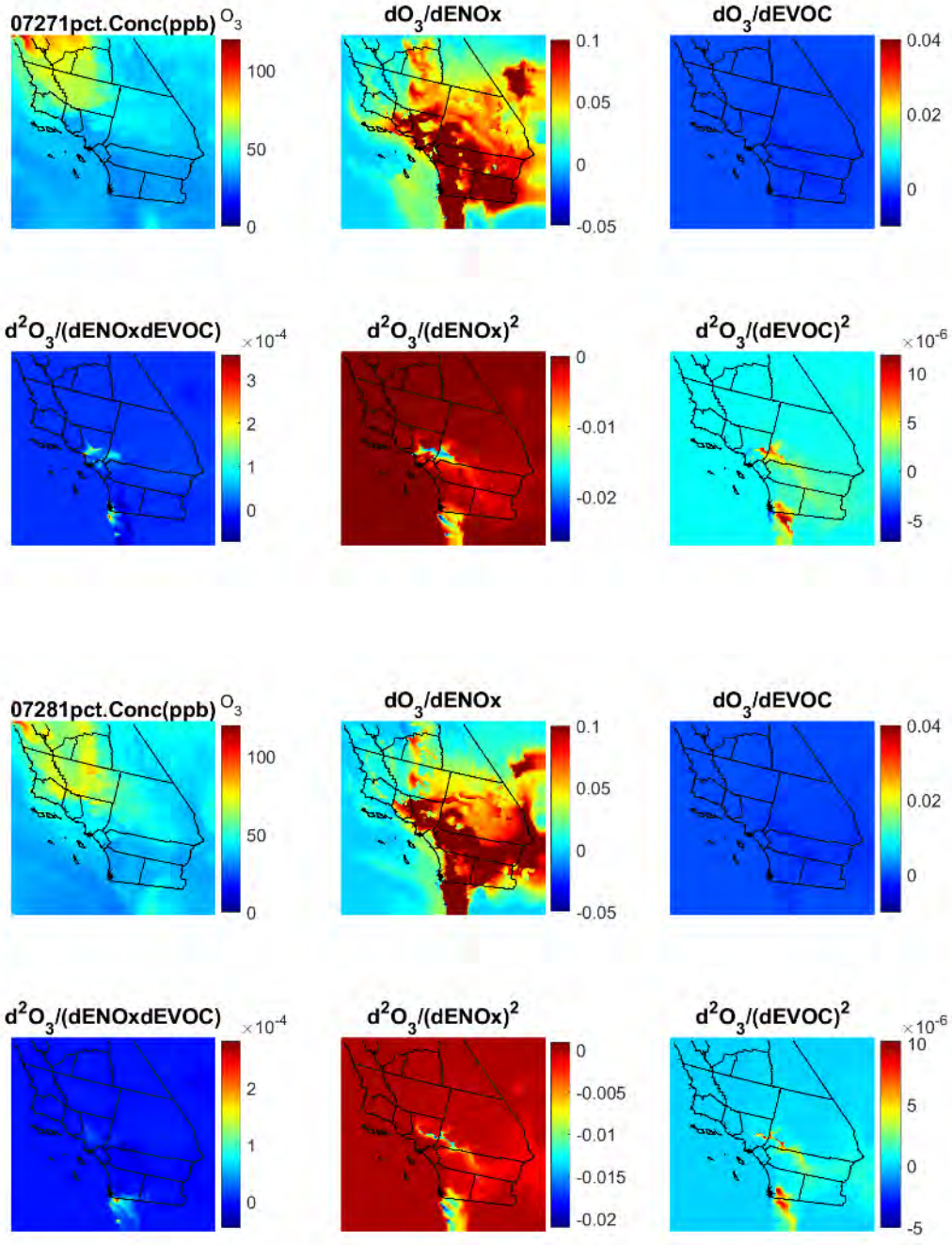

06021pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
10
5
0
d2O3/(dENOx)2
0
-0.02
-0.04
d2O3/(dEVOC)2
×10-5
2
0
-2
06031pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
15
10
5
0
d2O3/(dENOx)2
0
-0.02
-0.04
-0.06
-0.08
d2O3/(dEVOC)2
2
0
-2
-4
×10-5

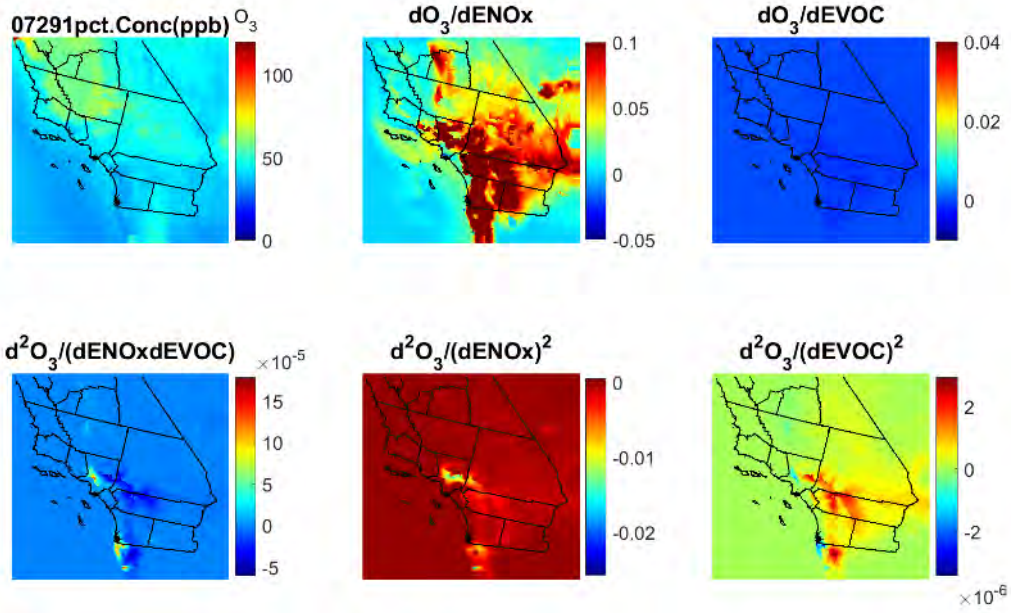

06041pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
15
10
5
0
d2O3/(dENOx)2
0
-0.05
-0.1
d2O3/(dEVOC)2
4
2
0
-2
-4
-6
×10-5
07201pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
10
5
0
d2O3/(dENOx)2
0
-0.01
-0.02
-0.03
d2O3/(dEVOC)2
0
-1
-2
-3
-4
×10-5


07211pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
15
10
5
0
d2O3/(dENOx)2
0
-0.01
-0.02
-0.03
-0.04
d2O3/(dEVOC)2
0
-2
-4
-6
×10-5
07221pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
8
6
4
2
0
d2O3/(dENOx)2
0
-0.02
-0.04
d2O3/(dEVOC)2
5
0
-5
-10
-15
×10-6


07231pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
4
3
2
1
0
d2O3/(dENOx)2
0
-0.01
-0.02
-0.03
d2O3/(dEVOC)2
0
-10
-20
×10-6
07241pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO /dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
4
3
2
1
0
d2O3/(dENOx)2
0
-0.01
-0.02
-0.03
d2O3/(dEVOC)2
5
0
-5
×10-6


07251pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
8
6
4
2
0
d2O3/(dENOx)2
0
-0.02
-0.04
d2O3/(dEVOC)2
2
0
-2
×10-5
07261pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
-1
d2O3/(dENOx)2
0
-0.01
-0.02
-0.03
d2O3/(dEVOC)2
×10-6
20
10
0


07271pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
3
2
1
0
d2O3/(dENOx)2
0
-0.01
-0.02
d2O3/(dEVOC)2
×10-6
10
5
0
-5
07281pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-4
2
1
0
d2O3/(dENOx)2
0
-0.005
-0.01
-0.015
-0.02
d2O3/(dEVOC)2
×10-6
10
5
0
-5


07291pct.Conc(ppb) O3
100
50
0
dO3/dENOx
0.1
0.05
0
-0.05
dO3/dEVOC
0.04
0.02
0
d2O3/(dENOxdEVOC)
×10-5
15
10
5
0
-5
d2O3/(dENOx)2
0
-0.01
-0.02
d2O3/(dEVOC)2
2
0
-2
×10-6

Appendix O: Spatial Distribution of 4 km-by-4 km CMAQ-HDDM Simulated Daily Averaged Ozone, CO, and VOC Concentrations Based on Different Boundary Conditions (BCs)

Four different simulations were conducted to assess how ozone, CO, NO_2, and VOC concentrations, as well as ozone-to-emission sensitivities, were impacted by alternate specifications of BCs. Four sets of simulations were conducted based on different emissions levels and BCs: 1) 2016 emissions with LA4 BC (Static, 2016); 2) 2016 emissions for the LA4 domain with BCs from the hemispheric CMAQ system (H-CMAQ 2016); 3) 1% 2016 NOx and VOC emissions for the LA4 domain (Static 1%); and 4) 1% 2016 NOx and VOC emissions for the LA4 and ZUSA emissions hemispheric CMAQ simulation (H-CMAQ 1%). For each set of simulations, the same 13-day peak ozone period (June 2 to June 4 and July 20 to July 29) was used to evaluate the impact of alternative BCs. We show the 4 km X 4 km gridded spatial distribution of simulated ozone, CO, and VOC concentrations based on each set of emissions and BCs for each day from July 20 to July 29.

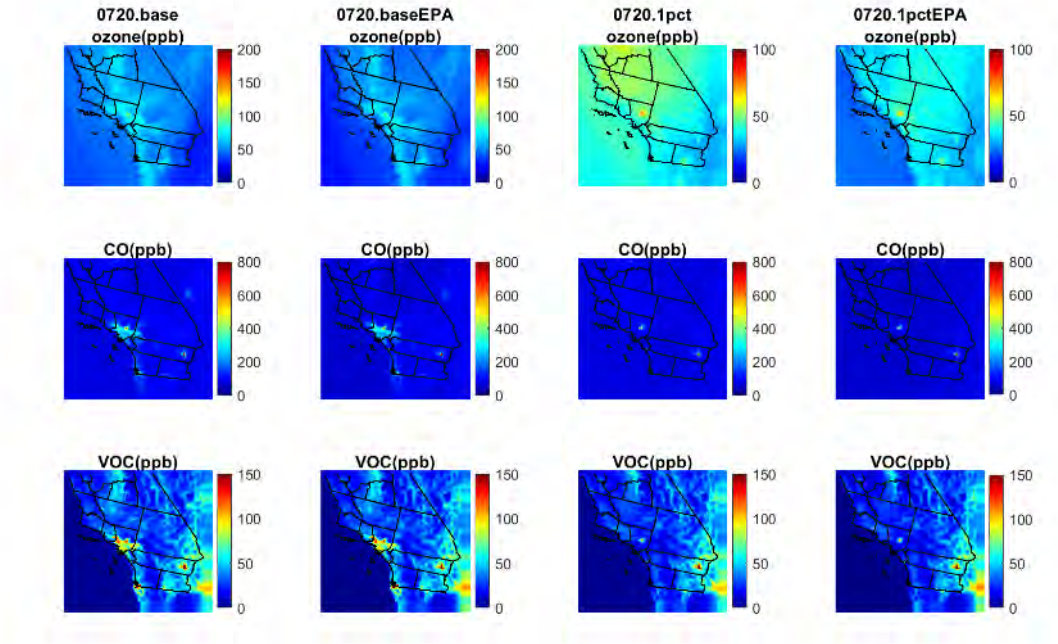
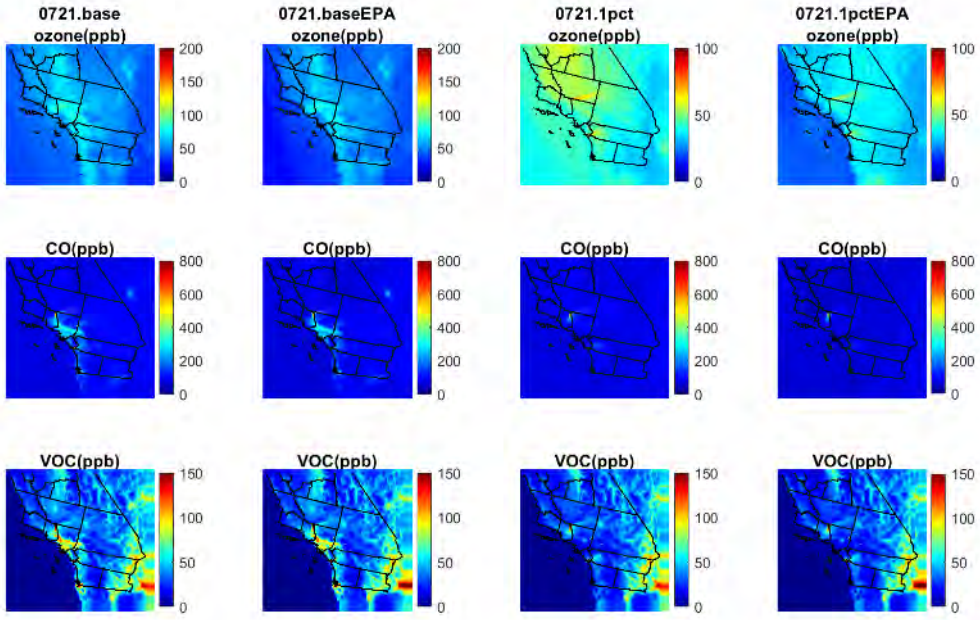
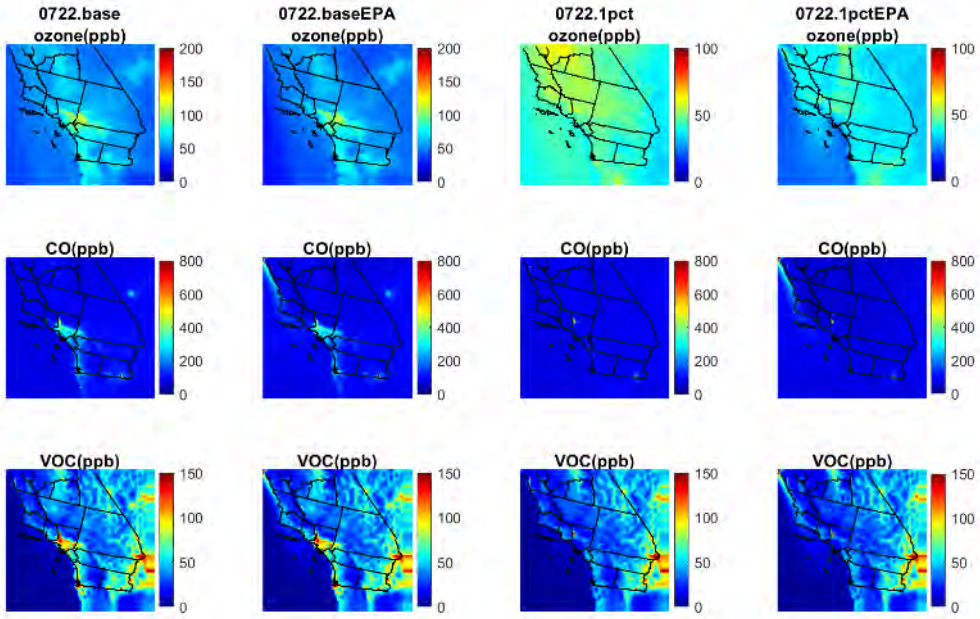
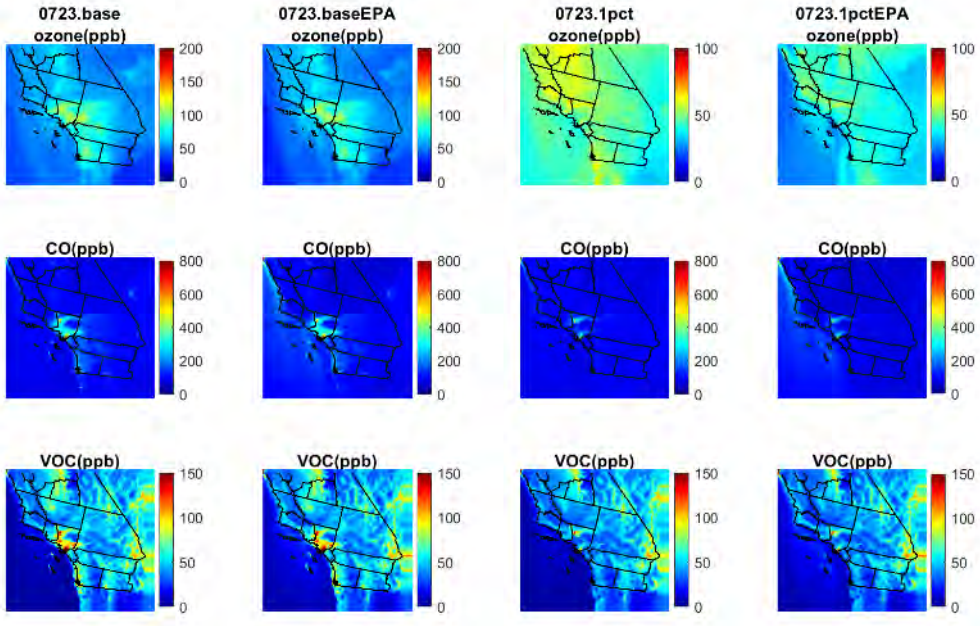
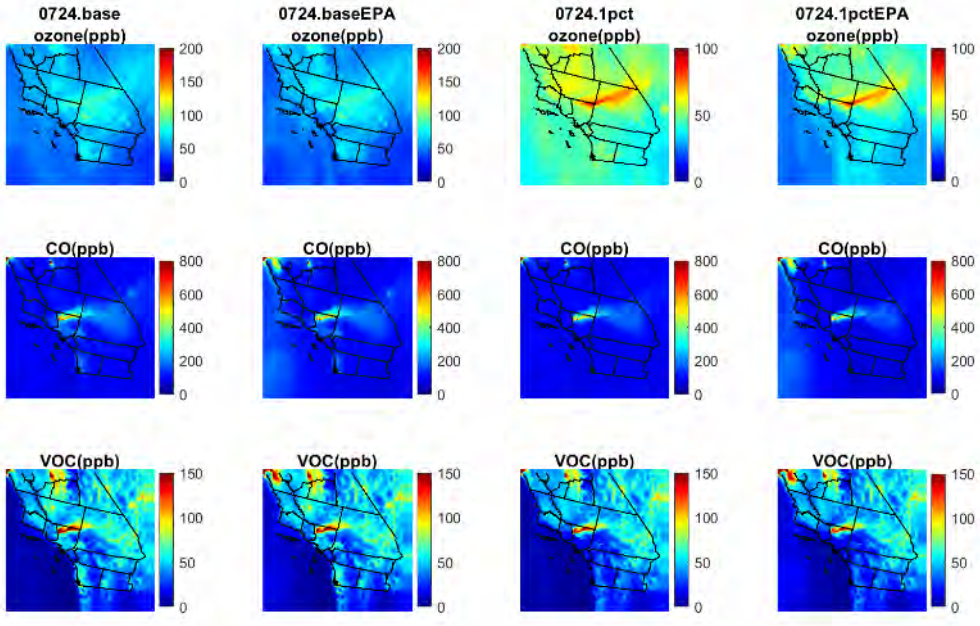


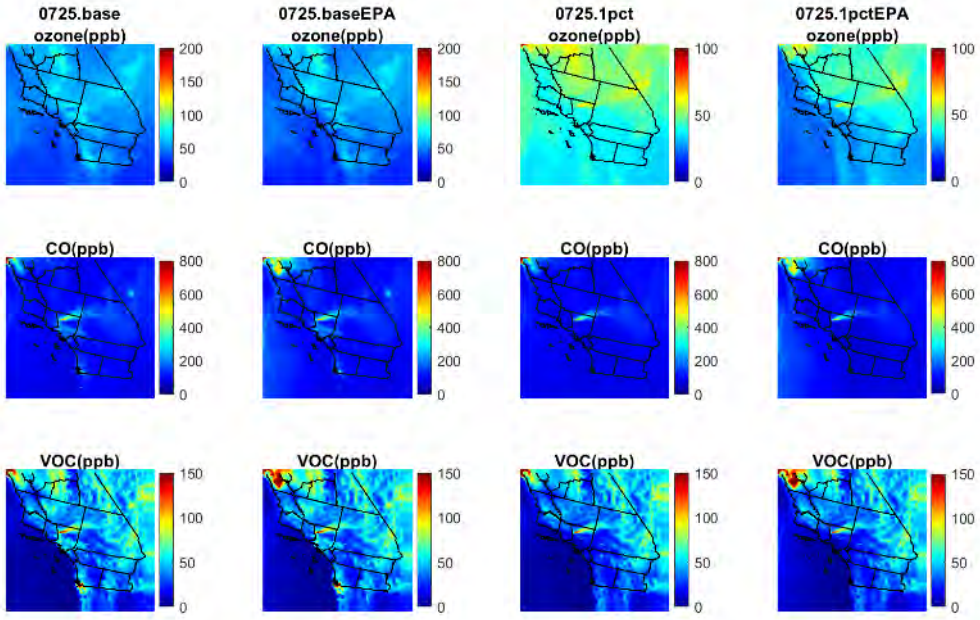
Figure O.1 Spatial distribution of simulated ozone (first row), CO (second row), and VOC (third row) concentrations based on each set of emissions and boundary conditions for each day. The first column shows the result based on static BCs and 2016 emissions. The second column shows the results based on H-CMAQ BCs and 2016 emissions. The third column shows the result based on static BCs and 1% 2016 emissions. The fourth column shows the results based on H-CMAQ BCs and 1% 2016 emissions. The date is July 20. Results for other days shown below in this section follow the same layout. The title of the upper-left sub-plot indicates the date of the simulation results being showed.

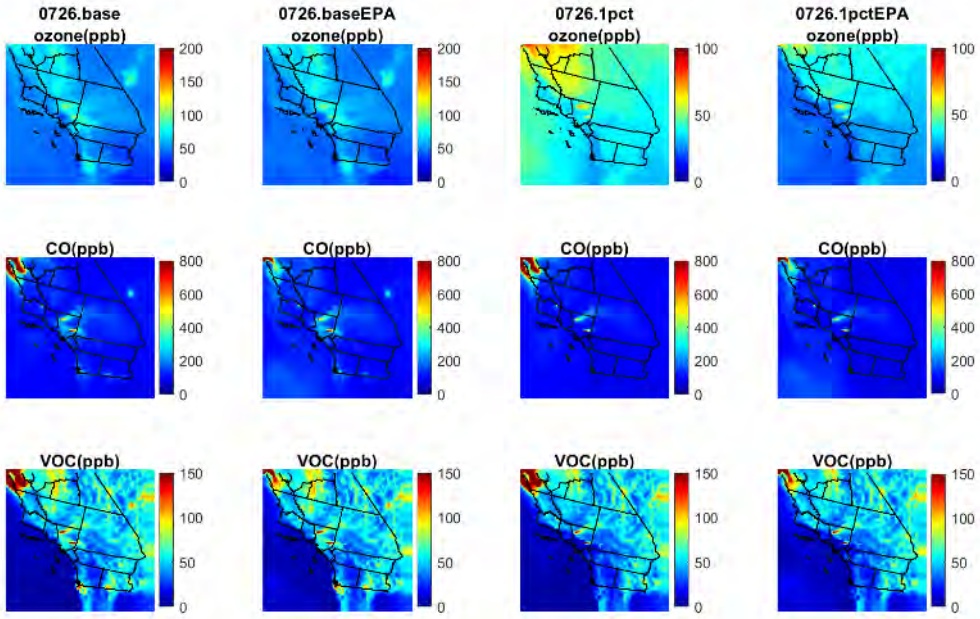

0721.base
ozone(ppb)
200
150
100
50
0
0721.baseEPA
ozone(ppb)
200
150
100
50
0
0721.1pct
ozone(ppb)
100
50
0
0721.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0

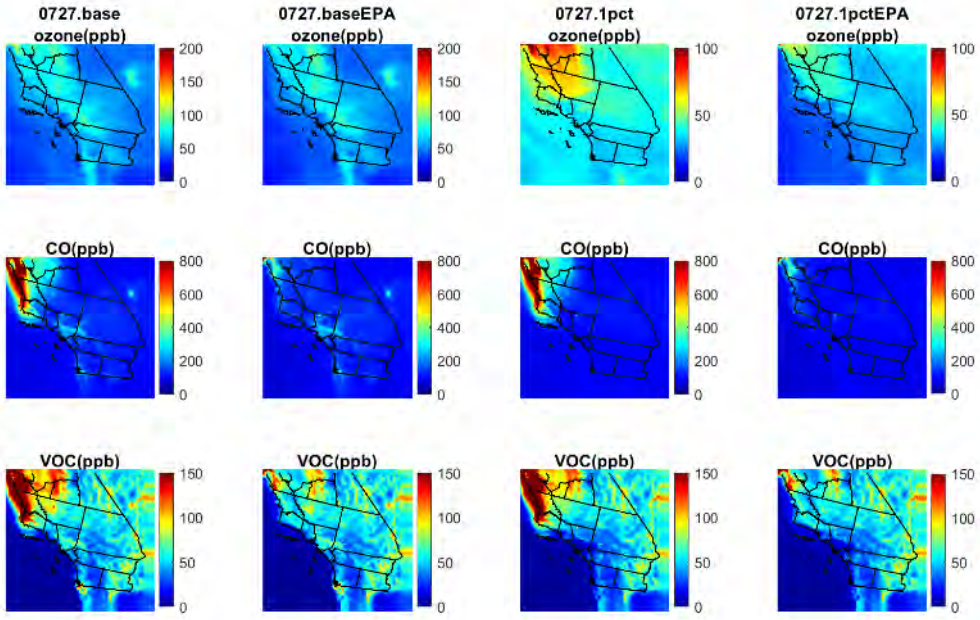

0722.base
ozone(ppb)
200
150
100
50
0
0722.baseEPA
ozone(ppb)
200
150
100
50
0
0722.1pct
ozone(ppb)
100
50
0
0722.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0

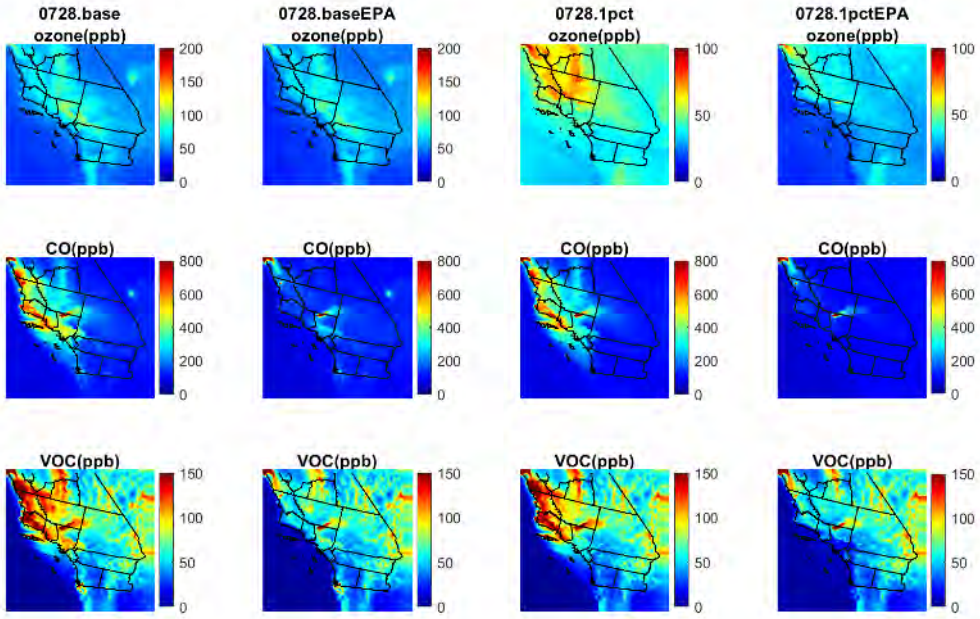

0723.base
ozone(ppb)
200
150
100
50
0
0723.baseEPA
ozone(ppb)
200
150
100
50
0
0723.1pct
ozone(ppb)
100
50
0
0723.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0

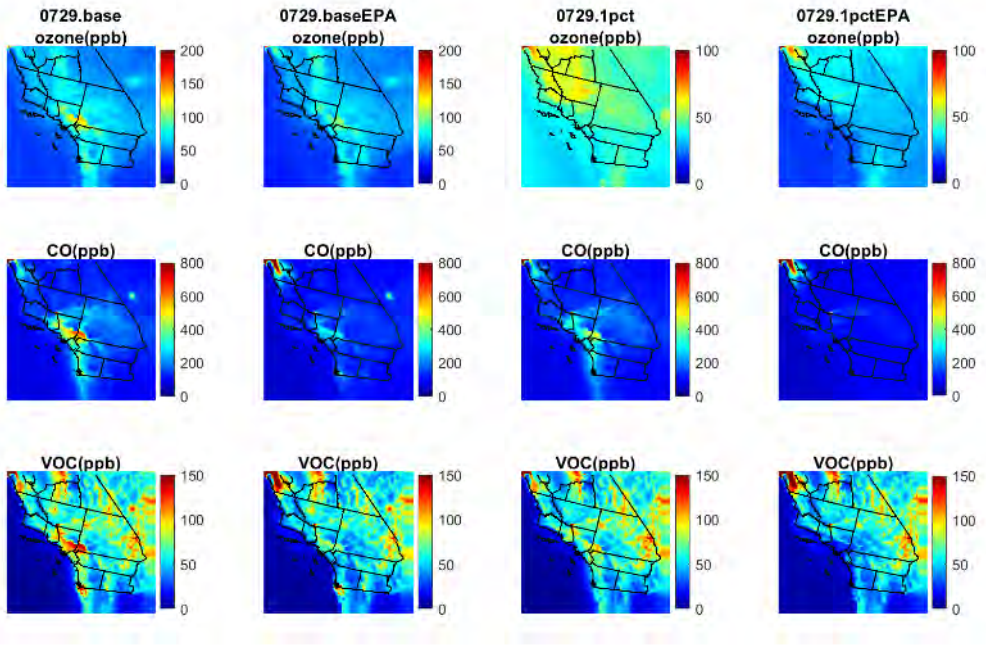

0724.base
ozone(ppb)
200
150
100
50
0
0724.baseEPA
ozone(ppb)
200
150
100
50
0
0724.1pct
ozone(ppb)
100
50
0
0724.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0


0725.base
ozone(ppb)
200
150
100
50
0
0725.baseEPA
ozone(ppb)
200
150
100
50
0
0725.1pct
ozone(ppb)
100
50
0
0725.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0


0726.base
ozone(ppb)
200
150
100
50
0
0726.baseEPA
ozone(ppb)
200
150
100
50
0
0726.1pct
ozone(ppb)
100
50
0
0726.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0


0727.base
ozone(ppb)
200
150
100
50
0
0727.baseEPA
ozone(ppb)
200
150
100
50
0
0727.1pct
ozone(ppb)
100
50
0
0727.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0


0728.base
ozone(ppb)
200
150
100
50
0
0728.baseEPA
ozone(ppb)
200
150
100
50
0
0728.1pct
ozone(ppb)
100
50
0
0728.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0


0729.base
ozone(ppb)
200
150
100
50
0
0729.baseEPA
ozone(ppb)
200
150
100
50
0
0729.1pct
ozone(ppb)
100
50
0
0729.1pctEPA
ozone(ppb)
100
50
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
CO(ppb)
800
600
400
200
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0
VOC(ppb)
150
100
50
0

Appendix P: Spatial Distribution of 12 km-by-12 km CMAQ-HDDM Simulated Daily Averaged Ozone, CO, and VOC Concentrations Based on Default static Boundary Conditions (BCs)

We show the 12 km X 12 km gridded spatial distribution of simulated daily averaged ozone, CO, and VOC concentrations based on 2016 emissions and default static BCs for each day from July 20 to July 29.

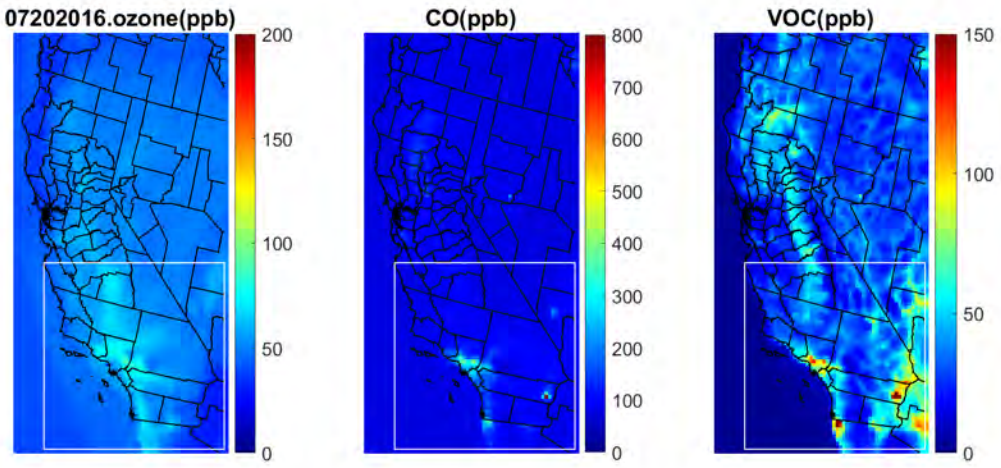
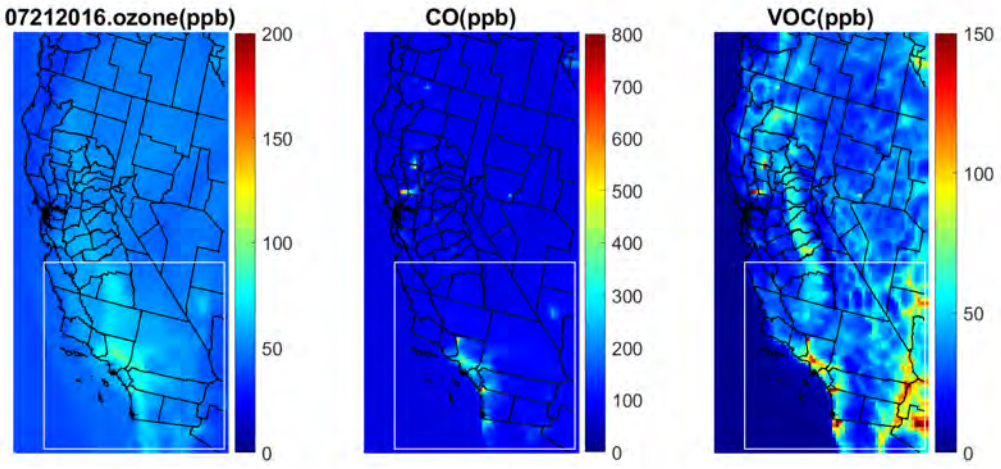
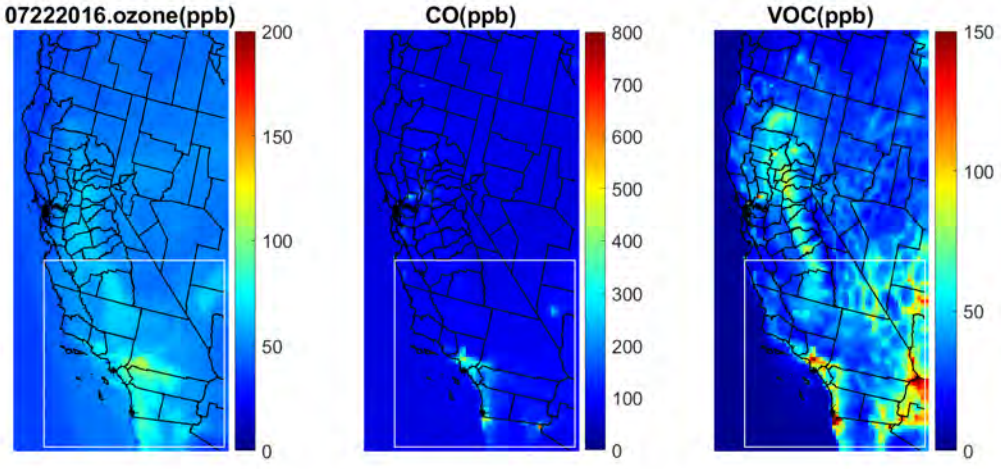
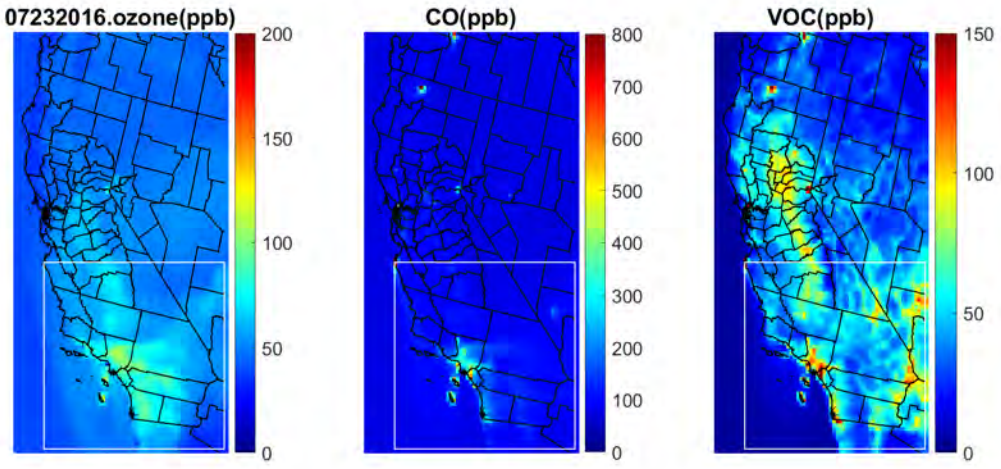
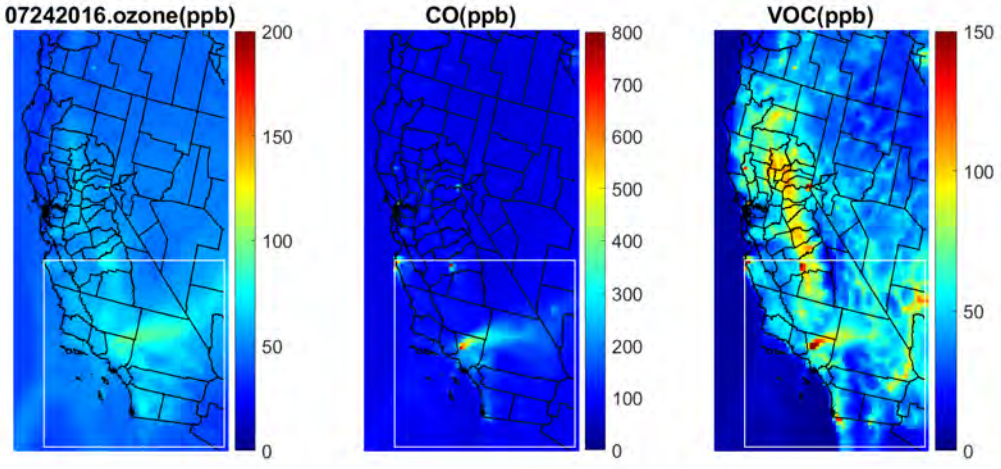


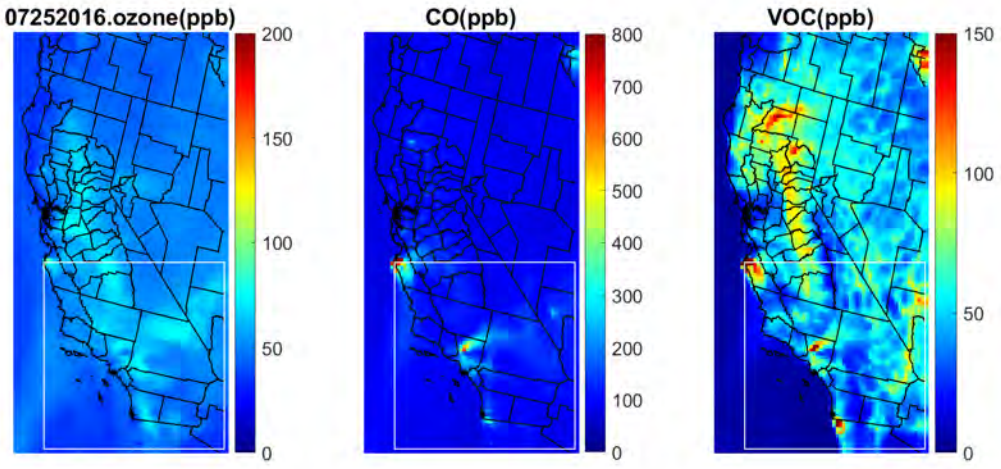
Figure P.1 The 12 km X 12 km gridded spatial distribution of simulated ozone (left), CO (middle), and VOC (right) concentrations based on 2016 emissions and default static BCs for each day. The plots show the domain containing California and the white box indicates the LA4 domain used for 4 km X 4 km simulations. The date is July 20. Results for other days shown below in this section follow the same layout. The title of the upper-left sub-plot indicates the date of the simulation results being showed.

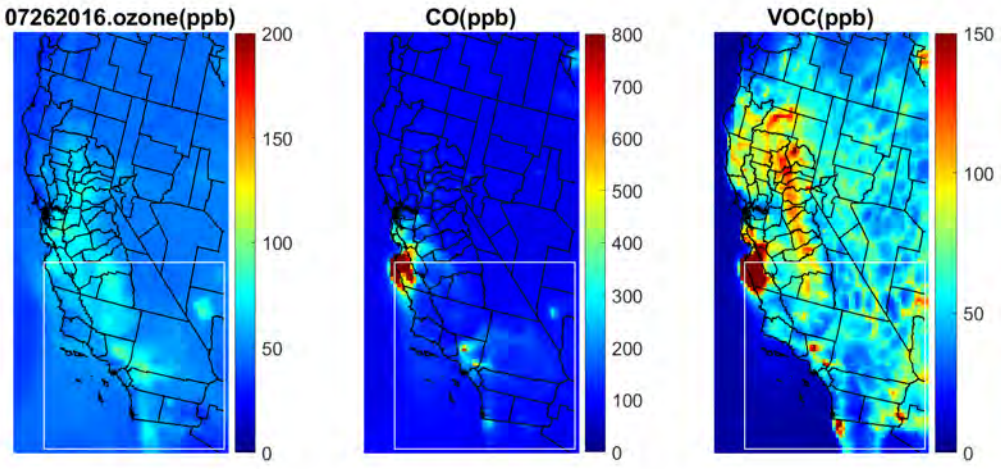

07212016.ozone(ppb)
200
150
100
50
0
CO(ppb)
800
700
600
500
400
300
200
100
0
VOC(ppb)
150
100
50
0


07222016.ozone(ppb)
200
150
100
50
0
CO(ppb)
800
700
600
500
400
300
200
100
0
VOC(ppb)
150
100
50
0


07232016.ozone(ppb)
200
150
100
50
0
CO(ppb)
800
700
600
500
400
300
200
100
0
VOC(ppb)
150
100
50
0


07242016.ozone(ppb)
200
150
100
50
0
CO(ppb)
800
700
600
500
400
300
200
100
0
VOC(ppb)
150
100
50
0


07252016.ozone(ppb)
200
150
100
50
0
CO(ppb)
800
700
600
500
400
300
200
100
0
VOC(ppb)
150
100
50
0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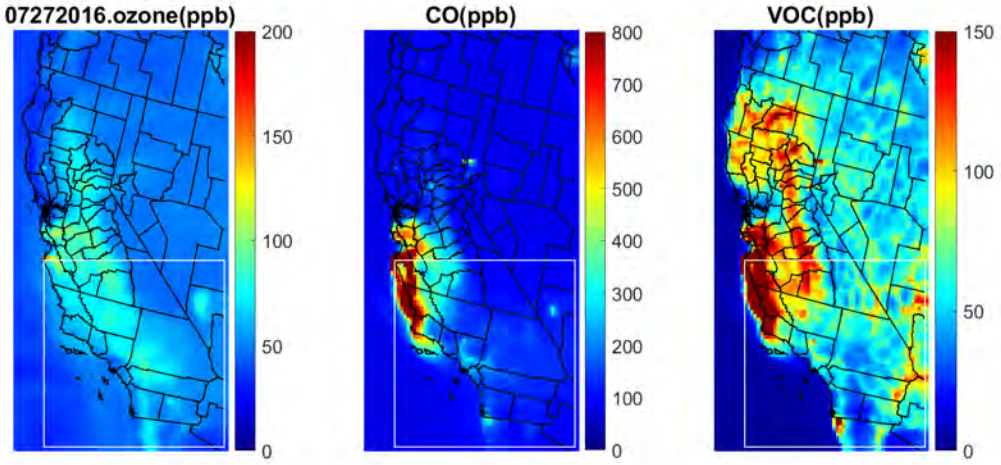
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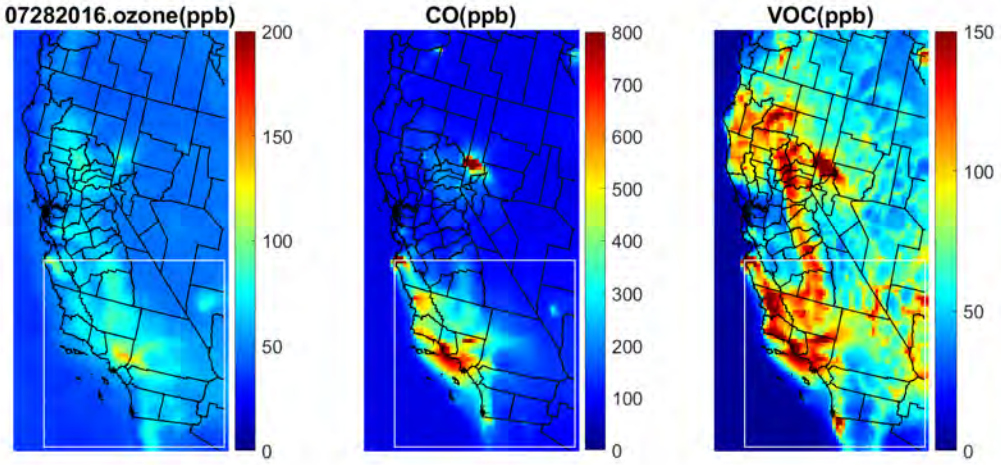
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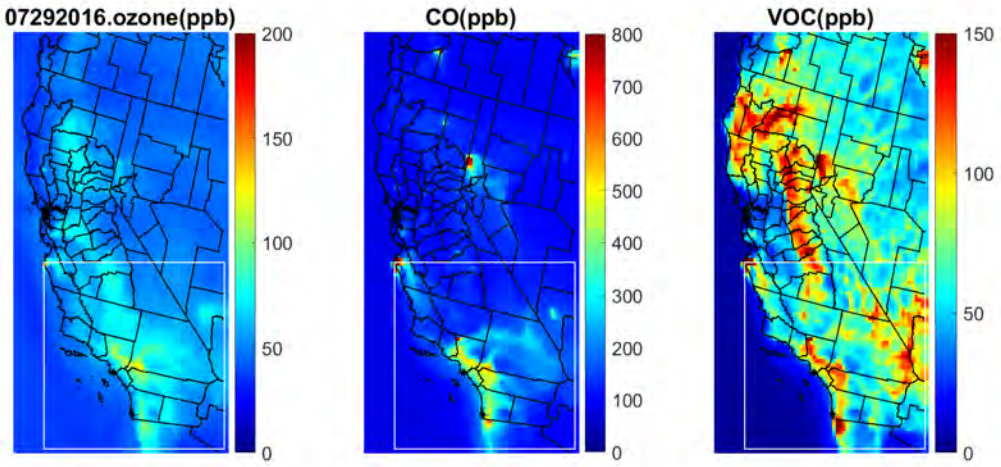
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